SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau)

1926-27

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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau.)

1926-27

REPORT OF THE DIRECTOR.

(D. Clouston, C.I.E., M.A., D.Sc.; and W. H. Harrison, D.Sc.)

I. Charge and Staff.

Charge. Dr. W. H. Harrison officiated as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, until 7th October, 1926, when Dr. D. Clouston, C.I.E., resumed the post while continuing to perform the duties of Liaison Officer between the Royal Commission on Agriculture and the Government of India and the Local Governments.

On relief by Dr. Clouston, Dr. W. H. Harrison took over, on 7th October,1926, the duties of the Joint Director and the Imperial Agricultural Chemist from Dr. W. McRae and Mr. J. N. Mukerji, respectively.

Staff. Mr. Arjan Singh continued to be in charge of the current duties of the Im perial Agriculturist until 22nd October, 1926, when Mr. G. S. Henderson returned from leave.

On return from leave on 16th November, 1926, Mr. T. Bainbrigge Fletcher resumed the post of Imperial Entomologist from Mr. M. Afzal Husain who reverted to the Punjab Agricultural Department.

Dr. F. J. F. Shaw having proceeded on leave for seven months from 22nd March, 1927, Khan Sahib Haji Abdur Rahman Khan was placed in charge of the current duties of the post of the Imperial Economic Botanist.

Rao Sahib Kasanji D. Naik was relieved of the current duties of the post of Secretary, Sugar Bureau, on 9th October, 1926, on the return of Mr. M. Wynne Sayer from leave.

Dr. J. Sen, who continued to be on deputation to the Forest Research Institute, Dehra Dun, as Bio-Chemist throughout the year, has been appointed substantively to the post of Plant Biological Chemist.

During the absence of Mr. P. V. Isaac, Second Entomologist (Dipterist), on leave from 1st July to 9th October, 1926, Mr. G. R. Dutt held charge of the current duties of the post.

II. Research.

The research work done by the Institute aims at establishing principles which can be put into general practice by provincial agencies. The more important work of the year under report is summarized below.

Botanical Section. The bearded hybrid wheat Pusa 52 and the beardless Pusa 80-5 are justifying their inclusion in the list of high yielding, strong-strawed, rust-resistant wheats recommended from Pusa. The former repeated in the Punjab its fine performance of the previous year in Bihar, the United Provinces and the Central Provinces, while the latter headed all varieties grown at Pusa with the excellent yield of 2,500 lb. per acre. Further trials with the American tobaccos Adcock and Burley have shown that a good yield of leaf can be assured by sowing and transplanting them earlier than the indigenous varieties. Burley when air-cured on racks in Bihar takes the rich mahogany colour characteristic of the best grades of this pipe tobacco. Flue-curing on a small scale, in a specially constructed tobacco barn, gave very encouraging results during the year. The burning and smoking qualities of the leaf and the economics of flue-curing are now under study. Crossing of certain Pusa types of linseed has given in the second generation hybrids which promise to combine the bold-seeded character with a habit suited to growth in the Gangetic alluvium. Pusa linseed Type 46 has proved superior in yield to all the varieties in cultivation in Iraq. An effort is also being made to evolve superior varieties of oats, barley, maize, gram, safflower, sesamum, peas, *mung* (*Phaseolus mungo*), *urid* (*P. radiatus*), *masur* (*Lens esculenta*), pigeon-pea and chillies, either through selective breeding or hybridization.

Chemical Section. The study of the movements of nitrates in the soil and subsoil, which had been in progress for some years in four areas under different cultural conditions, was concluded during the year. The results obtained point to the conclusion (1) that nitrification becomes very active when the rains begin and soon reaches its maximum, (2) that very considerable quantities of nitrates are, later on, washed into the subsoil and ultimately lost, (3) that very little of the large quantity

of nitrates produced during the early rains is utilized by the crops grown during that period, (4) that the nitrate produced during the later part of the monsoon is utilized by the cold weather crops, and (5) that there is no upward movement of the nitrates in the subsoil. Of the various manures experimented with, superphosphate produced canes the juice of which had the highest sucrose and the lowest glucose contents. This result was also reflected in the quality of *gur* (raw sugar) prepared. Various methods of curing tobacco were investigated during the year, and a sample of Pusa Type 28 rack-cured in the sun and protected from the dew was valued by an expert as the most suitable for cigarette manufacture. Further tests made with acetic ether indicate that it is the most effective solvent tried up to date for the detection of foreign fats in adulterated butter or *ghee*. The Physical Chemist has worked out during the year a method for determining the base exchange capacity of a soil.

Bacteriological Section. An investigation into the fluctuations in the total nitrogen content of different soils at Pusa has been started during the year. Fields in which Egyptian clover and maize are grown in rotation were found to have about double the nitrogen content of the plots in the experimental areas. Fermentation with soil and charcoal has proved to be as effective with *mahua* (*Bassia latifolia*) cake as with mustard cake. The superiority of the bonemeal-sulphur-sand-charcoal compost over ordinary bonemeal was again demonstrated when applied to soils carrying crops of mustard, oats and potatoes. Calcium cyanamide nitrifies as effectively as ammonium sulphate when the quantity of added nitrogen is only 5 mg. per 100 grm. soil ; with 30 mg. there is no nitrification for many weeks though ammonification takes place rapidly. Of the five plots tested, the one receiving green-manure and superphosphate was found to be the most efficient in fermenting cellulose. Bacteriological examinations of the milk supplied by the Pusa farm gave further evidence of the relation between the season of the year and the plate counts.

Mycological Section. A survey of the sugarcane growing stations in different parts of India has revealed the presence of mosaic disease in 28 localities among 47 Coimbatore cane seedlings and 2 thin and 38 tropical varieties of cane. Investigational work carried out during the year indicates that the disease behaves in India as in other countries ; that it is transmissible by sets and injection into the leaf and leaf-sheath ; that it passes from one variety to another and from cane to maize and *jowar* (*Andropogon Sorghum*), and that natural infection occurs. Observations made on a plot planted with mosaic and non-mosaic sets of Co. 213 suggest that roguing should be done in Bihar as early as the 1st of May when 75 per cent. of the mosaic plants should be visible. A disease of betel-vine, which is causing a loss of several lakhs per year in the plantations in Bengal, has been found to be due to the parasitism

of a species of *Phytophthora*, *Rhizoctonia solani* and *Sclerotium Rolfsii*. The relative importance of the part each fungus plays is still obscure, but it is most probable that the *Phytophthora* is the active agent during the monsoon, the *Rhizoctonia* in the cold weather and the *Sclerotium* in the hot weather. The roots and shoots of apparently healthy rice plants which had failed to form grains were found to have a most copious mycelium of a *Fusarium*. Wilts of pigeon-pea, linseed and gram are among other diseases under investigation.

Entomological Section. Experiments have been undertaken to determine which of the four suspected sucking insects is responsible for the spread of mosaic disease among sugarcane at Pusa. Work on cane-borers and their parasites was continued. Spraying with lead arsenate proved very successful in controlling the ravages of cockchafer beetles on plum trees, and of *Prodenia litura* and *Hellula undalia* on cauliflower seedlings. The use of mercury in stored wheat has proved effective in eliminating the danger of damage by weevils (*Sitophilus oryzae*) which amounts at times to 20 per cent. The physiological effect of mercury vapour on stored wheat is now under investigation. Work on the life-histories and distribution of Tabanidæ is being continued.

Agricultural Section. The permanent experiments being carried out in collaboration with other Sections of the Institute were continued. The sugarcane work taken over from the Sugar Bureau consists of varietal tests from the preliminary sorting-out stage to the mill trial in bulk. Experiments are also in progress to test the value of different fertilizers and different cultural methods, as well as to ascertain whether cane can be sown with advantage in October instead of in February as is the usual practice in North Bihar. As the monsoon was late and the rains deficient in quantity and defective in distribution, there was a slight drop in the yield of grain crops on the farm. There was, however, sufficient fodder on the farm to meet the requirements of the large herd of cattle. The abundance of luscious geeen food fed to the dairy herd has been reflected in the average yield per day per cow, which now stands at 15·9 lb. as against 14·4 in 1924-25. In the pure Sahiwal herd, six cows gave over 5,000 lb. each in a lactation period of 304 days, while among the half-bred progeny of rejected Sahiwal cows by Ayrshire bulls, the yields of the first six cows ranged from 8,000 lb. to 11,000 lb. In the former herd the average percentage of cows in milk was 68, while in the latter it was only 48. Thus a cross-bred cow not only gives more milk than her dam but also calves more frequently—an important advantage in commercial dairying.

Imperial Dairy Expert. There is a number of heavy-yielding cows with foreign blood on the Bangalore and Wellington farms, and the present policy is to adapt that strain to the needs of the country by mating them with Indian bulls of good milch pedigree. The resulting

progeny, though not such heavy yielders as their half-bred ancestors, is expected to be hardier and less susceptible to disease. At Karnal, pure herds of Thar-Parkar and Hariana cattle and Murra buffaloes are being built up by selective breeding. The Creamery at Anand has been equipped with an experimental milk condensing plant with a view to manufacturing sweetened and unsweetened condensed milk from village buffalo milk. The superiority of the western method of manufacturing *ghee* over the country method as practised in Gujarat was clearly proved by an experiment carried out at Anand during the year. The Imperial Dairy Expert continued to give Provincial Agricultural Departments, city municipal corporations and private individuals advice and assistance in technical matters connected with dairying and cattle-breeding. With a view to stimulating interest in cattle-breeding and dairying, he also delivered lectures illustrated by cinema films. At a lecture given by him at Delhi, His Excellency the Viceroy presided and addressed the meeting.

Physiological Chemist. Experiments on the nutrition of growing animals indicate that sorghum silage is eaten as readily as, and produces results in no way inferior to, Guinea grass ; that spear grass silage is consumed in amounts above the maintenance requirement while hay is not ; and that spear grass silage when supplemented by a small amount of cake promises to be an economical productive ration. At Karnal, rice straw again asserted its superiority over wheat straw. The digestibility of typical samples of Indian hay, the progressive changes occurring in the mineral and organic constituents of pasture grasses during maturing, and the mineral requirements of Indian animals are also under investigation.

Government Sugarcane Expert. The breeding work was concentrated on thick types of canes, and over 13,000 germinations were obtained. Of these, about 3,000 were saved for being grown for a full year's test on the new area acquired for this type of canes. Three fresh seedlings—two medium and one thick—were sent out for trial at provincial centres. The technique of cane-breeding received considerable attention during the year, and is being gradually perfected. The artificial rooting of canes evolved during the last season enables the isolation of arrows under cover in hybridization sheds. Such isolation has been found very suitable for carrying on cross-pollination in private plantations. With a view to ascertaining the effect of soil and climatic conditions on arrowing and arrow fertilities, an experimental plot has been planted with canes at Kallar near the foot of the Nilgiri range. It is proposed to establish similar plots elsewhere as facilities become available.

Sugar Bureau. As the Secretary of the Bureau has been relieved of the actual work of growing cane for testing purposes, he is now able to devote more time to the extension of the area under selected canes. With a view to obtaining further data on the Co. canes tested at Pusa,

he arranged during the year to establish small experiment plots at Lohat, Dowlatpur and Bhicanpur in Bihar, at the Karnal Cattle-breeding Farm in the Punjab, and at Sahmaw in Burma. The overseers of the Bihar department who are working under the supervision of the Secretary of the Bureau visited some 40 concerns, examined about 6,500 acres of cane in over 140 villages and assisted the growers in various ways. The Sugar Cable Service conducted by the Bureau on a self-supporting basis continues to receive the support of the trade.

III. Training.

Agricultural Research Institute, Pusa. The two-year post-graduate course was completed during the year under report by Messrs. G. I. Kavoor, B.Sc., and S. N. Nunjundiah, B.Ag., in Mycology, and by Messrs. A. T. Sen, M.Sc., and R. P. S. Chauhan, L.Ag., in Chemistry and Botany respectively. Mr. Kavoor, while under training, received the appointment of Agricultural Officer to the Andamans.

None of the 34 candidates for admission to the new session beginning on 1st November, 1926, was considered by the Selection Committee qualified for post-graduate training. A scholar of the Punjab Government was, however, subsequently admitted to the course in Botany. Together with five admitted in the previous year (two for Botany and one each for Agricultural Bacteriology, Mycology and Chemistry), there were thus six students under training at the close of the year. The one post-graduate student of the Imperial Institute of Animal Husbandry and Dairying was given short courses at Pusa in estate management, cattle-breeding, plant-breeding, plant diseases, etc., during the last three months of his period of training. Five other students also took short courses during the year.

Imperial Institute of Animal Husbandry and Dairying, Bangalore. The 15-month post-graduate course in animal husbandry and dairying, started on 2nd January, 1926, was completed by one student during the year under report. There were eight applicants for admission during the current session, of whom five were selected.

Fourteen students appeared for the Indian Dairy Diploma examination and nine were declared successful. Of the six fresh candidates, five were from the Allahabad Agricultural Institute and one from Bangalore ; while out of the eight students permitted to appear on a second occasion after a repeat course of six months, five came from Allahabad and three from Bangalore.

Short courses in cattle-breeding and dairying were provided for seven students from different provinces, and 10 Dairy Diploma students from the Allahabad Agricultural Institute also received technical instruction at the Bangalore and Karnal farms and the Anand Creamery.

IV. Publications.

Thirteen memoirs, three bulletins and four other publications were issued during the year, while 21 publications were in the press on 30th June, 1927. The publications issued dealt with subjects of general interest, such as the inheritance of characters in sugarcane and cotton breeding ; the varieties of rice found in Burma ; the effect of manuring on the vegetative and reproductive capacity of the seed ; the digestibility of Indian feeding stuffs, the nutrients required by Indian cattle for growth ; the absorption of moisture by soils ; the selection of Burma beans for low prussic acid content ; the treatment of hookworm infection in dogs, etc.

" The Agricultural Journal of India," which is issued every two months, continues to maintain its popularity among the class of readers for which it is intended.

With a view to stimulating and fostering the recently awakened interest in cattle-breeding and dairying, a quarterly journal called " The Journal of the Central Bureau for Animal Husbandry and Dairying in India " has been started from April, 1927. Articles less technical and scientific than those considered suitable for " The Agricultural Journal of India " will ordinarily find a place in the new journal, and they will aim at disseminating information regarding the progress made in establishing pedigree herds, the merits of the different breeds, new methods of growing and storing fodders in the dry state and as ensilage, animal nutrition, cattle diseases, courses of training in animal husbandry and dairying, etc. It is edited by the Agricultural Adviser to the Government of India, and the annual subscription for four issues is Rs. 2-8-0 only. For the first number of this Journal, His Excellency the Viceroy graciously contributed a Foreword.

V. General Administration.

Buildings. The work in connection with the scheme for concentrating the Botanical Section of the Institute in the area allotted to it, undertaken during the year, is in progress.

Library. In addition to 426 periodicals and 1,336 books, bulletins, reports and reprints received in exchange, 233 periodicals and 424 volumes of new books, pamphlets, etc., were purchased during the year. Out of 1,956 publications issued on loan, 203 were sent to officers of the Provincial Departments of Agriculture, teachers in various Universities and Colleges, etc. A Supplement to the Library Catalogue, corrected up to 31st December, 1926, has been sent to the press for printing.

Hospital. Medical relief was afforded to 271 in-patients and 9,730 out-patients during the calendar year 1926 as against 322 and 13,056,

respectively, in 1925. The marked decrease in cases of both types is to be ascribed to the charge now levied from patients not connected with the Pusa Estate. Among cases of the more important tropical diseases, 169 were of *kala-azar*, 79 of hookworm disease, 15 of cholera, 8 of plague, 6 of leprosy, 95 of dysentery and 685 of malaria. Of the 1,350 operations performed, 38 were " selected " ones.

The health of the residents on the Estate continued, on the whole, satisfactory, and there were no serious outbreaks of epidemic disease in the year under review.

The Kala-azar Commission visited Pusa during the year and conducted, in association with the Medical Officer of the Station, Mr. D. F. Michael, I.M.D., certain investigations into the transmission problem of the disease in and around the Estate.

VI. Accounts.

The total expenditure during the financial year ending 31st March, 1927, as shown below, was Rs. 7,56,984, as against Rs. 7,34,348 in the pre ious year.

	Rs.
General expenditure of the Institute, including the Office of the Agricultural Adviser	2,67,974
Botanical Section	47,506
Chemical Section	62,671
Bacteriological Section	50,524
Mycological Section	66,540
Entomological Section	54,135
Agricultural Section	1,68,750
Sugar Bureau	21,935
Sugar Cable Service	26,949
Total	7,56,984

The following are the principal items of expenditure met from the grant of Rs. 6,500 placed at the disposal of the Agricultural Adviser in 1926-27 for expenditure on special agricultural experiments :—

	Rs.
Purchase of apparatus for the Mycological Section	1,800
Grant to the Imperial Dairy Expert for exhibits sent to the Poona Show	2,000
Construction of an experimental tobacco-curing barn in the Botanical Area, Pusa	500
Construction of experimental silo pits at Karnal	540
Charges in connection with experiments in extracting fibres	246

The receipts during the year amounted to Rs. 87,041 as detailed below :—

	Rs.
Fees from students	2,322
Sale of farm produce	6,887
Sale of milk, cattle, etc.	36,726
Subscriptions to the Sugar Cable Service	26,008
Other receipts	15,098
TOTAL	87,041

VII. Royal Commission on Agriculture in India.

The Royal Commission on Agriculture in India visited Pusa in January, 1927, when the evidence of the Heads of the various Sections of the Institute, and of some European planters and an Indian zemindar was recorded. The Commission inspected the farm, the dairy, the laboratories, and some cane plantations in the neighbourhood, and were shown round the Samastipur Central Sugar Factory. The new Coimbatore varieties contributed three-fourths of the total quantity of cane crushed in this factory last season. Visits were paid, too, during the year to the Imperial Institute of Animal Husbandry and Dairying, Bangalore, the Imperial Cattle-breeding Farm at Karnal, the Government Experimental Creamery at Anand, and the Cane-breeding Station at Coimbatore. The Agricultural Adviser to the Government of India gave evidence at the initial meeting of the Commission held at Simla, while the Imperial Dairy Expert, the Physiological Chemist and the Government Sugarcane Expert were examined at their respective headquarters. The written memoranda submitted and the oral evidence given by the officers of the Imperial Department of Agriculture in India are to be found in Vol. I, Parts I and II of the interim report of the Commission already published.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(Khan Sahib Abdur Rahman Khan.)

I. Introduction.

Dr. Shaw held charge of the Section until 22nd March, 1927, on which date he proceeded on leave for seven months and Khan Sahib Abdur Rahman Khan assumed charge of the Section.

A sum of approximately Rs. 2,555 was realized from the sale of improved seeds, etc., and credited to Government during the past financial year.

The construction of the building sanctioned in the scheme for the concentration of the Botanical Section in the area allotted to it was commenced.

Training. Thakur R. P. Singh Chauhan completed his course of study and left the Section in October, 1926. Mr. Mahbub Alam and Mr. Sailesh Chandra Roy continued their training throughout the year. Both these students during their second year have been employed on the research work which is in progress in the Section and have done good work. Mr. Sawan Mal, a scholarship student, was sent by the Punjab Government and joined the Section in December, 1926. One student from the Institute of Animal Husbandry and Dairying, Bangalore, attended a special short course in plant-breeding during February and March.

II. Investigations.

The year 1926-27 was characterized by an exceptionally late monsoon, the first heavy rains falling about the middle of July. The rains ceased about 9th October, the total rainfall during the months of June, July, August, September and October being 34·44 inches. The distribution of rain during these months was bad, and as a result soil moisture was generally deficient for the cold weather crops. Germination was late in some cases and linseed cultures had to be resown after irrigation. The important crop returns obtained by the Botanical Section are shown in the following Table :—

Statement showing the outturn of various crops grown in rabi 1927.

Crop	Plot	Outturn of grain		Per acre
		Area in acres	Actual	
			Md. Sr. Ch.	Md. Sr. Ch.
Wheat—	Farm Punjab field—			
P. 12 . . .	1 . . .	0·25	2 31 4	11 5 0
„ . . .	2 . . .	„	2 32 12	11 11 0
„ . . .	3 . . .	„	4 8 4	16 33 0
„ . . .	4 . . .	„	3 30 14	15 3 8
„ . . .	5 . . .	„	2 26 14	10 27 8
„ . . .	6 . . .	„	2 27 0	10 28 0
„ . . .	7 . . .	„	4 12 10	17 10 8
„ . . .	8 . . .	„	4 10 6	17 1 8
„ . . .	9 . . .	„	4 21 2	18 4 8
„ . .	10 . . .	„	3 20 4	14 1 0
„ . .	11 . . .	„	3 5 4	12 21 0
„ . . .	12 . . .	„	2 30 4	11 1 0
„ . . .	13 . . .	„	3 23 12	14 15 0
„ . . .	14 . . .	„	2 32 12	11 11 0
„ . . .	15 . . .	„	3 4 2	12 16 8
„ . . .	16 . . .	„	2 36 2	11 24 8
„ . . .	17 . . .	„	2 18 4	9 33 0
„ . . .	18 . . .	„	2 34 6	11 17 8
„ . . .	19 . . .	„	2 34 8	11 18 0
„ . . .	20 . . .	„	3 1 0	12 4 0
„ . . .	21 . . .	„	2 35 14	11 23 8
„ . . .	22 . . .	„	3 7 12	12 31 0
„ . . .	23 . . .	„	3 36 14	15 27 8
„ . . .	24 . . .	„	4 29 4	18 37 0
„ . . .	25 . . .	„	4 35 8	19 22 0
„ . . .	26 . . .	„	3 34 14	15 19 8

Statement showing the outturn of various crops grown in rabi 1927 —concld.

Crop	Plot	Outturn of grain			Per acre		
		Area in acres	Actual				
			Md.	Sr. Ch.	Md.	Sr.	Ch.
Wheat—							
P. 12	27	0·25	4	21 2	18	4	8
„	28	„	3	15 14	13	23	8
P. 4	Barah 6	0·44	4	9 0	9	24	0
„	„ 4	0·75	12	32 0	17	3	0
„	„ 5	0·47	7	12 0	15	21	0
„	„ 7	0·49	4	37 8	10	3	0
„	„ 2 (portion)	0·50	8	26 0	17	12	0
„	Riverside (eastern)	0·76	12	34 0	16	36	0
„	Riverside (western)	0·74	14	35 0	20	4	0
P. 52	Pentagonal	4·22	65	32 0	15	24	0
„	Pentagonal (eastern border).	0·11	2	1 0	18	16	0
„	Pentagonal (southern border).	0·14	2	17 0	17	13	0
P. 80-5	Lawn No. 2	0·37	11	11 0	30	19	0
P. 90	„ No. 3	0·34	8	35 12	26	6	0
Gram—							
T. 17	Orchard 1A	0·48	6	10 0	13	1	0
„	„ 2C	0·71	11	2 0	15	23	0
T. 25	N. T. G. 9	0·2	1	20 0	7	20	0
„	„ 10	0·5	8	26 0	17	12	0
T. 6	Orchard 1B	0·48	7	18 0	15	21	0
T. 9	N. T. G. 6	0·23	2	12 8	10	2	0
T. 4	„	0·23	1	16 0	6	3	0
Rahar—	Orchard 5B	0·6	10	4 8	16	34	0
„	„ 5A	0·62	9	16 8	15	7	0
„	„ 4B	2·0	27	13 8	13	27	0
„	„ 4A	2·03	33	22 8	16	21	0

Wheat. The following approximate quantities of Pusa wheats were distributed to private growers and Provincial Departments of Agriculture :—

	Md.
Pusa 4	66
„ 12	78
„ 52	60
„ 80-5	15
„ 90	9

Pusa 80-5 gave 27 maunds 14 seers of grain per acre at the Gurdaspur Agricultural Station, and Pusa 52, 23 maunds 35 seers of grain per acre at Hansi.

The second hybrid generation of the cross Pusa wheats and Federation was grown and selections were made. Arrangements have been made to grow certain of the late flowering selections in the N.-W.F. Province where these types will have a better chance of success than in Bihar. The Pusa selections are being examined for rust resistance by the Imperial Mycologist. The study of the biometrical data of the Pusa wheats was continued.

Oats. Nine types of Pusa selections together with a Meerut variety were grown on a field scale in plots of 0·2 acre each. The yields and weights in bushel obtained were as follows :—

Statement showing the outturn of oats in 1927.

Plot	Area in acres	Type of oats	Outturn of grain		Outturn of straw		Weight of grain per bushel in lb.
			Actual	Per acre	Actual	Per acre	
			Md. Sr.	Md. Sr.	Md. Sr.	Md. Sr.	
Orchard . .	0·2	1-1	6 17	32 5	7 25	38 5	36·0
6 A & 6B . .	„	4-1	6 2	30 10	7 15	36 35	36·5
„ . .	„	7-1	6 22	32 30	7 24	38 0	35·0
„ . .	„	7-3	6 7	30 35	7 18	37 10	35·0
„ . .	„	10-4	7 7	35 35	10 22	52 30	35·5
„ . .	„	12-1	7 21	37 25	9 28	48 20	35·5
„ . .	„	14-2	7 14	36 30	9 21	47 25	36·5
„ . .	„	19-1	6 32	34 0	9 4	45 20	34·5
„ . .	„	19-3	6 7	30 35	9 10	46 10	34·5
„ . .	„	Meerut	6 5	30 25	9 2	45 10	35·0
	Total .		66 14		87 9		
	Average per block (0·2 acre)		6 25		8 29		

The three best types will be tried under farm conditions during the next season.

Six American varieties of oats and six British varieties were imported and tried on a small scale. The former proved to be of medium

maturity and all flowered successfully and ripened their grain. The grain of these American types is, however, small and thin, and it is not likely that any of them will prove superior to the local Bihar oats. The European oats are all much too late in their date of flowering to be of use in Bihar. They are, however, markedly superior to Indian oats in the quality of their straw and are therefore being used as parents in crosses with local oats. The first hybrid generation of a cross between the Scotch Potato oat and two of the Pusa selections was raised and studied. The plants were difficult to raise and only two were secured, but both proved vigorous and showed characters intermediate between those of the parents. The habit and the quality of the straw of the Scotch Potato oat seem dominant, while the period of maturity fortunately inclines towards that of the Indian parent. One fact which must not be lost sight of in the crossing of Indian oats with exotic types is that in many cases this involves species hybridization. This is the case in the present instance, the Scotch Potato oat belonging to the species *Avena sativa*, while the Pusa selection is *Avena sterilis*. Crosses between these two species have been successful in the past in the case of the Lachlan, Terran and Bathurst Early, three hybrid oats produced in New South Wales, and there is no reason why the cross with the Indian type should not prove equally useful. It is at present too soon to give a definite opinion on this point.

Barley. A varietal trial of 27 pure line cultures of barley was made and their average yields as well as weights per bushel are shown in the following Table. Some biometrical data have been collected and correlations of certain characters are being studied.

A number of crosses were also made between the hulled and hulless varieties and some seed has been obtained which will be tried next year.

Much damage was done this year by the incidence of *Helminthosporium* disease which was very severe in many varieties. Many cultures were badly lodged owing to the late rains and heavy winds in the last week of February.

Average yields and weights per bushel of barley culture, 1927.

Culture	Plot	Actual outturn of grain in beds 2 (4′×50′)			Calculated yield per acre			Weight per bushel in lb.
		Md.	Sr.	Ch.	Md.	Sr.	Ch.	
B-4 . . .	Barah 3 .	0	15	8	42	8	0	43·0
21-1 . . .	„ .	0	14	5	39	0	0	46·3
19-2 . . .	„ .	0	12	15	35	10	3	50·0
9-5 . . .	„ .	0	12	8	34	2	8	46·0

Average yields and weights per bushel of barley culture, 1927—concld.

Culture	Plot	Actual outturn of grain in beds 2 (4′× 50′)	Calculated yield per acre	Weight per bushel in lb.
		Md. Sr. Ch.	Md. Sr. Ch.	
C-1 . . .	Barah 3 .	0 12 3	33 8 8	45·0
23-10 . . .	„ .	0 12 0	32 28 0	45·5
16-8 . . .	„ .	0 11 14	32 14 6	51·0
20-7 . . .	„ .	0 11 12	32 12 0	45·8
17-2 . . .	„ .	0 11 6	30 19 14	48·75
24-6 . . .	„ .	0 10 14	29 25 6	44·0
22-2 . . .	„ .	0 10 6	28 10 14	46·9
10-10 . . .	„ .	0 9 0	24 21 0	45·0
14-1 . . .	„ .	0 8 13	24 0 9	44·0
5-6 . . .	„ .	0 7 12	21 4 0	41·7
18-3 . . .	„ .	0 7 4	19 30 4	45·25
15-10 . . .	„ .	0 6 12	18 9 0	47·3
1-10 . . .	„ .	0 6 6	17 15 0	51·0
28-8 . . .	„ .	0 6 0	16 14 0	47·5
12-5 . . .	„ .	0 5 15	16 7 3	46·75
4-2 . . .	„ .	0 5 14	16 0 6	48·25
Huskless Ramdana .	„ .	0 8 13	24 0 9	64·3

Maize. As a result of the work of the previous season selections were reduced to two varieties, one white-seeded and the other yellow-seeded. Eight cobs, one cob from each plant, of each variety were sown, for an ear-to-row test. About fifty plants were grown from each cob. In studying the crop, the observations were confined to the silking and pollination period, plant height, the height at which cobs appear, seed weight, and the number of cobs per plant. The observations show that the characters studied vary considerably in the different progenies. In the yellow-seeded variety the progeny of cob No. 2, and in the white-seeded variety the progeny of cob No. 9 have surpassed the other progenies in many desirable characters. Since only half the seeds of these particular cobs were sown, the reserve seeds will be used next year for multiplication and further selection of these types. In studying the silking and pollination periods of the progeny of the different cobs, no

marked differences were noted, hence observations on these two points will be discontinued.

A study of the effect of inbreeding in maize was carried out and seeds from self-pollinated plants of both the yellow and white-seeded races were sown and the progenies studied. The population raised from selfed seeds of the white-seeded variety showed a distinct degeneration in respect of plant height, height at which cobs appear and yield ; such degeneration was not conspicuous in the yellow-seeded race. The populations raised from selfed plants appeared very uniform. Yellow-seeded plants invariably possess red butteress roots and white-seeded plants have green. Self-pollination was repeated this year and the progeny will be studied during the coming season. Controlled cross-pollination between different plants of the same culture was carried out and the resulting progenies will be compared with those raised from selfed plants.

An American Dent corn was tried but failed to grow under Bihar conditions.

Tobacco. The second hybrid generation of the crosses between Pusa Type 28 and the imported tobaccos Adcock and White Burley was grown and studied. About 8,000 plants were raised and numerous selections were made from this population. The selections were made chiefly with the object of obtaining a vigorous hardy plant which would retain the colour and the burning and smoking qualities of the imported tobaccos. Over the whole population, records were taken of the flowering date, leaf area, height and number of leaves per plant.

Trials of the imported American tobaccos, Adcock and Burley, were continued during the year under review with special reference to their yielding power and smoking qualities. The experience in previous seasons had suggested that these tobaccos did better in Bihar if sown and transplanted considerably earlier than is usual in the local practice. In the past season sowing was carried out about the end of July and transplanting about the end of August, or first week of September, and very good crops of both Adcock and Burley were raised. The Burley yielded at the rate of 1,300 lb. of dry leaf per acre and was air-cured on racks. The leaf obtained was of excellent colour and quality. This tobacco is a pipe tobacco and there seems to be no difficulty in Bihar in curing the leaf to the rich mahogany colour which is characteristic of the best grades of this tobacco. The Adcock tobacco yielded at the rate of 900 lb. of dry leaf per acre and the problem of curing this leaf is by no means as simple as in the case of the Burley.

The experiments of the previous season had suggested that the uncertain climate of Bihar during the curing season rendered it impossible to produce bright leaf from the Adcock tobacco by air-curing on racks. At the same time a small experiment in flue-curing had shown

that there might be considerable possibilities in this method for the successful production of high grade bright leaf in Bihar. With the object of making a thorough trial of flue-curing, a tobacco barn was constructed in the Botanical Section on the lines of those used in the tobacco-growing districts of America. Such a barn is practically a small closed room with a furnace built into one wall and an iron flue pipe running round the room and passing into a chimney. The temperature of the room is regulated by the amount of fuel consumed in the furnace and also by the opening and closing of certain ventilators cut in the wall. The principles governing the use of such a barn are broadly that the tobacco must be harvested at the right stage of maturity and must consist of uniform leaf and that the correct moment in the curing process must be selected for raising the temperature of the barn. The early sowing of the Pusa tobacco resulted in the crop being ripe in January and several curings were carried out in the barn with results which were very satisfactory as regards the colour of the cured leaf, a considerable proportion of which was of a bright lemon yellow colour. The burning and smoking qualities of the leaf are now under test and the economics of the process are being studied. The production of bright tobacco in Bihar as a commercial success is a matter of the relation between the yield per acre, the cost of curing and the price of the leaf. The experiments carried out in the Botanical Section suggest that the yield per acre will be satisfactory and the work of next season should give some insight into the other two factors.

Oil-seeds. Crossing between certain types of Pusa linseeds was commenced in January 1925, and the study of the second hybrid generation of crosses between certain of the Pusa types of linseed was carried out during the past season and the inheritance of characters in the colour of the petals, filaments, anthers, style and stigma and seed has been partly worked out. The inheritance of colour in these organs appears to depend on the interaction of a group of factors. Satisfactory Mendelian ratios were obtained and the investigation will be continued in the next hybrid generation. Several of the selections show promise of giving types of linseed which will combine the bold-seeded character with a habit suited for growth in the Gangetic alluvium.

During the year 1925 a new type (No. 124) of linseed appeared in the Botanical Area in cultures of Type 12. This linseed, while possessing the vegetative and floral characters of Type 12, was found to have a white seed, which on analysis proved to contain 3 per cent. more oil than that of Type 12. The origin of this variant is unknown, the fact that so far it has bred true being against the ordinary hypothesis that it is the result of a natural cross. In the past season, it was tried on a small plot in comparison with three standard varieties. The results are shown in the following statement.

Variety experiment with linseed.

(Lawn plot No. 1).

Linseed type	Area of each plot in acre	1st SERIES (WEST)		2nd SERIES (EAST)		Oil content percentage		REMARKS
		OUTTURN OF GRAIN		OUTTURN OF GRAIN				
		Actual	Per acre	Actual	Per acre	in 1927	in 1926	
		Sr. Ch.	Md. Sr.	Sr. Ch.	Md. Sr.			
46 . .	0·05	25 0	12 20	22 0	11 0	39·59	..	
12 . .		23 8	11 30	10 8	5 10*	39·39	38·94	* The plot was damaged by the roots and shade of a banian tree.
121 . .		29 0	14 20	29 0	14 20	41·07	41·77	
124 . .	,,	25 8	12 30	22 8	11 10	40·91	42·05	
Bihar wilt resistant.	,,	20 0	10 0	19 0	9 20	39·19	..	This variety was received from the Director of Agriculture, Bihar and Orissa, for trial.

It will be noticed that the new variety has given better results than Type 12, though the difference in the percentage of oil is not so great as it was last year. The oil analysis was kindly made by the Imperial Agricultural Chemist.

Several types of Pusa linseeds have been under trial at the Rustam Government Farm, Iraq and the Department of Agriculture in Iraq reports that the Pusa types have given eminently satisfactory results in comparison with other varieties under test. A trial of five Pusa types (Nos. 15, 29, 46, 50 and 55) having shown that Pusa Type 46 was in Iraq superior to others, it was compared with four other varieties of linseed with the following result :—

Variety of linseed	Yield in lb. per acre
Casablanco Morocco	678
United Provinces	631
Central Provinces	655
Bombay	715
Pusa 46	939

Pusa 46, therefore, has thus proved greatly superior in yield to any of the other varieties of linseed in Iraq. Casablanco Morocco was formerly the best and is the most popular linseed in Iraq. It has, however, been beaten by Pusa 46 both in yield and oil-content. The trial is to be repeated in the next season and if the results obtained show agreement with those already reported, the local Department of Agriculture proposes that further experimental work with linseed in Iraq shall

be devoted to the introduction and testing of the Pusa types. Types 12 and 121 have already been sent to Iraq for comparison with Type 46 and seed of the new linseed (Type 124) is also being sent.

The study of types of safflower was continued, and trials of the spineless types as a fodder for cattle are being carried out by the Department of Agriculture, Bihar and Orissa.

The work of isolating the unit species of sesamum was continued and a study of sepaloidy and sterility in the flower was carried out by one of the students (Mr. Sailesh Chandra Roy).

Rahar (*Cajanus indicus*). The isolation of unit species in this crop is being continued. About 20 different grains, 18 types of flower and 12 different pods have been found. Natural cross-fertilization appears to take place in this crop on a large scale, as out of 265 different cultures which were raised from bagged plants only 76 were found to be almost pure.

The investigation, which has for its object the isolation of a type of *rahar* which will prove resistant to wilt disease, was continued in collaboration with the Imperial Mycologist on the lines laid down in the last Anual Report. The progress of the work is satisfactory, but a detailed report is not required this year.

Gram. The second hybrid generation of the cross between Type 2 and Type 18 was grown this year, and the inheritance of the qualitative and quantitative characters was studied. It appears that the red colour in the margin of the leaflets, the petiole and the flower of Type 18 is dependent on a single factor, the ratio of the red and green plants in the F_2 generation being approximately as 3 : 1. This factor is responsible for the appearance of all the red colour—both in the vegetative and floral parts.

The study of the different size characters (*e.g.*, size of leaves, pod, grain, etc.) is also in progress, but the data is yet incomplete.

The F_1 generation of another cross between T. 1 and T. 25 was also grown. The red colour of T. 25 is dominant to its absence in T. 1, as was expected from the results of the cross between T. 2 and T. 18. It is interesting to note that the size of the leaflet of the F_1 plants is intermediate between the 2 parents (T. 1 having larger leaflets than T. 25) ; the inheritance of this character will be studied in the F_2 generation.

Some new crosses have also been made this year and they are as follows :—

T. 2 (large, white)×T. 9 (small, white)
T. 13 (small, blue)×T. 2 (large, white)
T. 25 (small, red)×T. 13 (small, blue)

The study of unit species in this crop was continued and a number of new types have been isolated and classified. The types will be grown

again next season for a final comparison. The seed from which these types are descended was collected from various parts of India in 1925 and 1926.

Peas. A tentative classification of the types of Indian peas has been made and will be tested next year. Some crosses of white-flowered and red-flowered types have been carried out and will be used to demonstrate the laws of inheritance to students. The red colour of the flower and red in the axil of the leaf was dominant in the F_1 generation. Three different types of red-flowered peas were used as parents, the distinction between them being based on the colour and markings of the testa. In all cases the seed of the F_1 generation resembled that of the red-flowered parent.

Lentils (*Ervum lens*). Single plant cultures were tried and some interesting differences were observed for the selection of unit species. Very little splitting was found in single plant cultures. Notes on the pollination of this crop have been taken and some crosses were also made between white and violet flowered varieties. Cultures of the types and first generation hybrids will be raised next season.

Mung (*Phaseolus radiatus* Linn.). Selections were made and single plant seed selected of different kinds of *mung*. Samples of black, greying black; bright and dull yellow, dark green, green and sage coloured seeds were obtained and pure line cultures are being maintained.

Urid (*Phaseolus Mungo* Linn., Mant.). Pure line cultures of this crop are also being tried. Some samples, however, failed to set normal seed and the causes of this are under investigation.

Sugarcane. Canes were raised from the first batch of seedlings received from Coimbatore and were analysed by the Imperial Agricultural Chemist at the close of the growing season. The results obtained with the 13 best canes were as follows :—

Analyses of some Coimbatore sugarcane seedlings grown at Pusa.

No.	Average weight of a cane in lb.	In Juice															
		Brix corrected				Percentage Sucrose				Percentage Glucose				Purity			
Dates	15-1-27	8-11-26	27-11-26	18-12-26	15-1-27	8-11-26	27-11-26	18-12-26	15-1-27	8-11-26	27-11-26	18-12-26	15-1-27	8-11-26	27-11-26	18-12-26	15-1-27
1	1·727	14·97	15·01	16·03	18·23	11·89	12·03	13·78	15·98	1·43	1·05	0·54	0·34	79·42	80·12	85·97	87·66
2	1·889	..	..	..	20·49	..	..	..	19·08	..	..	..	0·23	..	..	..	93·12
3	2·300	14·43	16·23	17·09	17·95	10·74	12·53	13·92	15·11	2·37	2·00	1·46	0·94	74·41	77·21	81·46	84·17
4	1·560	16·98	17·54	17·66	19·31	13·87	14·78	14·9	16·75	1·42	1·04	1·06	0·68	81·64	84·26	84·39	86·73
5	2·675	14·91	13·42	17·23	18·17	11·45	9·93	14·58	15·36	1·85	1·56	1·17	0·79	76·8	74·02	84·61	84·55
6	2·001	..	..	..	17·32	..	..	..	15·05	..	..	..	1·21	..	..	..	86·88
7	2·116	12·99	14·48	15·64	18·23	9·74	11·13	13·2	15·38	1·9	1·55	1·31	0·74	75·02	76·83	84·4	84·38
8	1·681	15·61	15·42	17·08	17·26	12·48	12·25	14·21	14·32	1·33	1·43	1·02	1·31	79·96	79·46	83·17	82·99
9	1·814	..	..	..	19·08	..	..	..	16·77	..	..	..	0·85	..	..	..	87·86
10	2·293	..	..	..	18·57	..	..	..	16·55	..	..	..	0·31	..	..	..	89·11
11	2·447	16·5	17·74	18·91	19·98	13·37	15·12	16·36	18·58	1·77	1·30	0·97	0·60	81·04	85·21	86·53	93·01
12	2·15	..	..	..	18·96	..	..	..	17·97	..	..	..	0·35	..	..	..	94·78
13	1·360	..	..	..	19·59	..	..	..	17·61	..	..	..	0·42	..	..	..	89·91

These canes have been selected for further trial on a field scale and have therefore been handed over to the Imperial Agriculturist for multiplying in the cane nursery which has been established on the Pusa farm. New canes from a second batch of seedlings are being raised in the Botanical Area and will be analysed and selected next year.

Hemp (*Cannabis sativa*). As outlined in the last Annual Report, the study of the effect of external stimuli on the sex-ratios in hemp was continued, and the diversity of results obtained proved the most interesting feature of the experiment. A study of 1,870 plants raised from single plant cultures showed that the average ratio of male, female and monoecious individuals was as 1 : 2·1 : 0·63 in the first census and as 1 : 2·34 : 0·93 in the final. While in 1,690 plants raised from mixed seed the average ratio was 1: 3·44 : 0·96 in the first and 1 : 3·51 : 1·24 in the final census. The first census was taken when the plants had just started flowering and the final census was made two months later.

Ceiselsky claims that hemp pollinated with fresh pollen produces a great preponderance of staminate plants, but that in hemp pollinated with stale pollen a preponderance of carpellate plants is obtained. Six plants were bagged and pollinated with fresh pollen last year and another six plants were bagged and pollinated with stale pollen. A progeny of 217 plants was obtained from the seed of the former and of 234 plants from that of the latter. The final ratios of male, female and monoecious individuals were 1: 2·98 : 0·74 and 1 : 3 : 1·32 respectively. These results, therefore, do not support Ceiselsky's conclusions.

Of 103 plants mutilated or otherwise treated only 8 plants this year changed their sex, in the sense in which Pritchard has presented this phenomenon. The question whether this change is a true reversal of sex or not is still to be thoroughly investigated. Observations on about 3,600 plants seem to show that there is a general tendency towards monoeciousness in Indian hemp. About 21·7 per cent. of the total population have shown monoecious characters this year. Of these the majority developed a few secondary flowers of the opposite sex, at a time when their normal flowering was nearly completed. This suggests that there is a regular tendency in hemp towards monoeciousness, which may go to the extent of about 21-22 per cent. of the total population, and that those plants which have been said to reverse their sex under mutilation or other stimuli may after all belong to this group of plants and that such stimuli are not after all responsible for the reversal of sex.

Of the 20 cultures raised from single plant bagged seed, one culture (No. H-17) showed the smallest tendency towards monoeciousness, having only about 1·5 per cent. of monoecious plants. It has, therefore, been thought desirable to multiply the seed of one bagged plant from this culture and to continue the work on the progeny of this, so as

to eliminate as far as possible this conflicting factor of natural monoeciousness.

Adlay (*Coix lachryma-Jobi*). The seeds of the wild form of this crop, better known in the West as Job's Tears, are hard and bead-like and are in common use for making necklaces and ornaments, but a form with soft hulls, easily removed from the kernel, is assuming increasing importance in the Philippines as a food plant. It is said that it yields a product which approximates wheat in food value, being far better balanced than either rice or corn. At the instance of the Agricultural Adviser to the Government of India a sample of the best variety of Adlay was procured from the Philippine Islands and a trial of it was made against *juar*. The Adlay crop was so stunted and poor that we cannot recommend its growing as a field crop at least in Bihar.

Patwa (*Hibiscus cannabinus*). The Pusa types of *H. cannabinus* were maintained. From close observations of the year under report it appears that the shortening and curling up of the leaves which causes sterility in *patwa* plants is due to insects (*Pseudococcus* sp.). Perhaps the cultures from selfed seed having less vigour are more liable to insect attacks than those from unbagged seed.

III. Publications and Programme.

Publications.

Shaw, F. J. F. . .	Summary of the Progress of Research in Agricultural Botany for the year ending 31st March, 1927, for inclusion in the Report for the Privy Council.
Howard, G. L. C., and Abdur Rahman Khan.	The Indian Types of *Lathyrus sativus* L. (*khesari, lakh, lang, teora*). *Memoirs of the Dept. of Agri. in India, Bot. Series*, XV, No. 2. (*In the press.*)

Programme for 1927-28.

Investigations will be continued on the lines indicated in this report on the following crops—wheat, oats, maize, tobacco, chillies, pulses, hemp, etc. Experiments in the curing of tobacco and on the incidence of wilt disease in *rahar* will also be carried out. In collaboration with the Imperial Mycologist experiments are being laid down which have for their object the isolation of disease resistant types in other important crops. The training of students will proceed as in past years.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison D.Sc.)

I. Administration.

Mr. J. N. Mukherjee held charge of the Section till 7th October, 1926, when Dr. W. H. Harrison reverted from the post of Offg. Agricultural Adviser to the Government of India and took over charge.

Dr. J. Sen, Supernumerary Agricultural Chemist, continued to be on deputation to the Forest Research Institute, Dehra Dun as Bio-Chemist throughout the year. He has been appointed substantively to the post of Plant Biological Chemist in this Section.

II. Training.

Mr. A. T. Sen, M.Sc., the senior postgraduate student, completed his two years' course on 31st August, 1926. Mr. Sher Singh Mangat, M.Sc., who joined in November 1925, is continuing his studies here and is to complete his full term by the end of September, 1927. No students were admitted this year, as the applicants for admission were below the standard required.

III. Meteorology and Drain-gauges.

The usual meteorological and drain-gauge records were maintained. The crops and 81 samples of drainage waters from the gauges were examined in the usual manner.

IV. General analytical work and assistance given to other Sections.

A. The following samples were analysed and reported upon :—

Soils	15
Manures	22
Feeding stuff	2
Oil-seeds	5
Sugarcanes	175
Sugar-beet	1
Milk	2,644
Waters	7
Oils	3
Indigo	19
Miscellaneous	2
Total	2,895

The sample of sugar-beet was analysed at the request of the Agricultural Officer, North-West Frontier Province, Peshawar. Four samples of soil were received from the Baroda State and two from Government Cinchona Plantation, Burma.

A sample of well water was received from the Patiala State and four samples of sewage and well waters from the Baroda State. A sample of night soil was sent by the Superintendent, Horticultural Division, New Delhi, for the estimation of its manurial value. A sample of *copra* (dried coconut kernel) was received from the Chief Commissioner, Andaman and Nicobar Islands.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Ten samples of manure, and 2,644 samples of milk were examined.

Botanical Section. Two samples of manure, 5 of oil seed and 68 samples of sugarcane were analysed.

Mycological Section. Four samples of sugarcane were examined in connection with the mosaic disease of canes.

Sugar Bureau. One sample of manure, one of water and 103 samples of sugarcane were analysed.

V. Research.

The determination of available phosphoric acid in soil. The investigation into the estimation of available phosphoric acid in soil by the potassium carbonate method of extraction was further studied by Mr. Das, and a comparison with Dyer's citric acid method was made of various types of Indian soils of known agricultural history. A few typical results are given below.

Description of plots	Per cent. available phosphoric acid	
	By citric acid	By potassium carbonate
I. Alkali soils.		
Sukkur Agricultural Station, Sind—		
Good soil	0·0031	0·0071
Bad „	0·0198	0·0043
Good „	0·0206	0·0069
Bad „	0·0326	0·0036

Description of plots	Per cent. available phosphoric acid	
	By citric acid	By potassium carbonate
II. Calcareous soils.		
Manjri Dry Farming Station, Bombay—		
Control	*Nil.*	0·0013
Farmyard manure	*Nil*	0·0014
Poona Agricultural College Farm, Bombay—		
Farmyard manure + safflower cake — Good soil	0·0262	0·0052
„ „ + „ „ — Bad soil	0·0280	0·0049
No manure	0·0024	0·0023
Farmyard manure	0·0011	0·0034
Nagpur College Farm, Central Provinces— (Yields of crop in ascending order)		
No manure	0·0016	0·0005
Urine	0·0010	0·0008
Dry excreta	0·0002	0·0011
Dung + Urine	0·0009	0·0012
(Yields of crop in ascending order)—		
Scarified	0·0109	0·0023
Country ploughed and scarified	0·0076	0·0024
Inversion ploughed and scarified	0·0150	0·0032
Akola Government Farm, Berar— (Yields of crop in descending order)		
Castor cake + super	0·0041	0·0011
„ „ + „ + lime	0·0006	0·0009
„ „ + lime	0·0006	0·0006
III. Humus or hill soils.		
Hill soils, Simla—		
Polo ground	0·0622	0·0348
Race course	0·1208	0·0424
Hill soils, Cloud End, Mussoorie—		
Soil No. A	0·035	0·0104
„ No. C	0·117	0·0348

Description of plots	Per cent. available phosphoric acid.	
	By citric acid	By potassium carbonate
IV. Non-calcareous soils.		
Cuttack Government Farm, Orissa—		
Best land	0·0050	0·0074
Medium „	0·0036	0·0068
Poor „	0·0009	0·0036
Government Farm, Adhartal, Jubbulpore, C. P.—		
Unmanured	0·0013	0·0021
Sann-hemp + super	0·0012	0·0026
Sabour Government Farm, South Bhagalpur, Bihar—		
Unmanured, Poor land	0·0191	0·0052
„ Fertile land	0·2822	0·0172
Ammonium sulphate	0·1305	0·0171
Kharhara Farm, South Bhagalpur, Bihar—		
Unmanured	0·0008	0·0019
Ammonium phosphate	0·0016	0·0023
Nawada Government Farm, District Gaya, Bihar—		
Unmanured	0·0004	0·0005
Super	0·0012	0·0012

These results show that the values obtained by acid extraction in the case of humus and non-calcareous soils agree amongst themselves, whereas the results are erratic in the case of calcareous and alkali soils. In contrast to this, the values obtained with alkaline extraction show no irregularities with all the different types. The method of alkaline extraction would therefore appear to be of greater general applicability and of greater utility for the evaluation of calcareous and alkali soils. The results obtained to date in this investigation are being prepared for publication.

The movement of nitrates in the soil and sub-soil. The study of this subject has been continued in connection with three areas under different cultural conditions, *viz.*, pasture, fallow and unirrigated cropped land, and the investigation was concluded in October last. Three hundred and twenty-four samples of soil and sub-soil were collected during the period July to October and examined for their moisture and nitrate contents. The results generally confirm the conclusions drawn in previous years and point to the conclusion that—(1) nitrification becomes

very active when the rains begin and early reaches a maximum, (2) with the subsequent heavy later rains very considerable quantities of nitrates are washed into the sub-soil and ultimately lost, (3) very little of the large quantity of nitrate produced during the early rains is utilized by the crops grown during the period, (4) the nitrate produced during the latter portion of the monsoon is, however, not lost and is utilized by the cold weather crops, and (5) there is no appreciable upward movement of these sub-soil nitrates.

This investigation has now been stopped and the results obtained are in process of tabulation and preparation for publication.

The adulteration of butter and ghee. The prevalence of adulteration of butter and *ghee* in India makes it particularly desirable to have a quick and reliable method of detection. Considerable attention has been given by Mr. Sanyal to this subject during the past year, and he has been successful in working out a method which promises to be of considerable utility.

Briefly, the method is based upon the fractional precipitation of the glycerides of the higher fatty acids from a solution in dry acetic ether by alcohol of defined strength under strictly controlled conditions of concentration and temperature. Under these conditions, pure butter and *ghee* yields no precipitate, whereas the addition of animal fat produces a precipitate closely proportionate to the amount added. The test is quick in operation and an estimation of the amount of adulteration can be made with fair accuracy and is in agreement with the results obtained by the cryoscopic method of determining the depression of the freezing point of solution of the fats in benzene.

Butters and *ghees* of known origin and purity as well as commercial samples of butter have been examined, and this phase of the investigation will be extended. In addition, it has become necessary to test the method on butter and *ghee* produced from animals fed on varied concentrate and in particular to those fed on cotton-seed in order to determine if the accuracy of the test is thereby affected. It is hoped that the results will be ready for publishing in the course of a few months.

The effect of manurial ingredients on the quality of sugarcane juice and gur. In order to study the effect of manures on the quality of sugarcane juice, Co. 313 was grown in duplicate plots to which was applied superphosphate, sulphate of potash, sulphate of ammonia, calcium cyanamide and mustard cake. The manures were applied in two doses, once in March and again in July, and periodic analyses of the canes were carried out from November until harvest in February 1927.

The experiment was only of a preliminary character, but the following tentative conclusions may be drawn from the results obtained :—

(1) The cane in all the plots matured about the beginning of January and maintained the sucrose content and purity until harvest.

(2) Superphosphate produced canes the juice of which had the highest sucrose and lowest glucose contents, and was closely followed by sulphate of potash.

(3) Sulphate of ammonia and cyanamide depressed the sucrose content and increased the glucose, the former giving the most extreme values.

(4) Mustard cake had an effect very similar to cyanamide in the early stages but later there was a marked improvement in the sucrose content and the purity of the juice.

In order to estimate the effect of these manures on the quality of the *gur* produced, the different juices were all clarified by the phosphoric acid and lime method under uniform conditions and the temperature of boiling was controlled. As a result, it was found that the *gurs* produced varied in quality according to the quality of the juice from the several manurial plots.

Thus, the superphosphate plot yielded a good quality *gur* containing 82·5 per cent. sucrose, 3·0 per cent. glucose and 2·7 per cent. ash, whereas that from the sulphate of ammonia plot yielded values of 76·5 and 3·5 respectively. Sulphate of potash yielded a *gur* of similar quality to that by superphosphate, whilst the products from the cyanamide and mustard cake plots were intermediate in character.

These experiments are being repeated during the current year.

Experiments with tobacco curing. Mr. Mukherji has carried out an investigation to find out the effect of varied methods of curing tobacco on the quality of the product, an investigation which is of particular importance because of the wide variations in climatic conditions which occur in North Bihar during the curing season.

Two varieties of ordinary country tobacco and Pusa tobacco Type 28 were grown under as uniform conditions as possible and finally cured by the following methods :—

(1) Ground cured in the sun.

(2) Ground cured in the sun but protected from night dews after the first six days.

(3) Rack cured in the sun.

(4) Rack cured in the sun and protected from dews.

(5) Rack cured in the sun for 8 days and subsequently rack cured in the shade.

(6) Rack cured in the shade throughout.

(7) As in No. 5 but without stems.

All the rack cured tobaccos were protected from the west winds by means of thatch.

The samples of these cured tobaccos were examined and valued by the Indian Leaf Tobacco Development Co., Dalsing-Sarai. Tobacco cured by method No. 4 was classed as the best, followed in order of

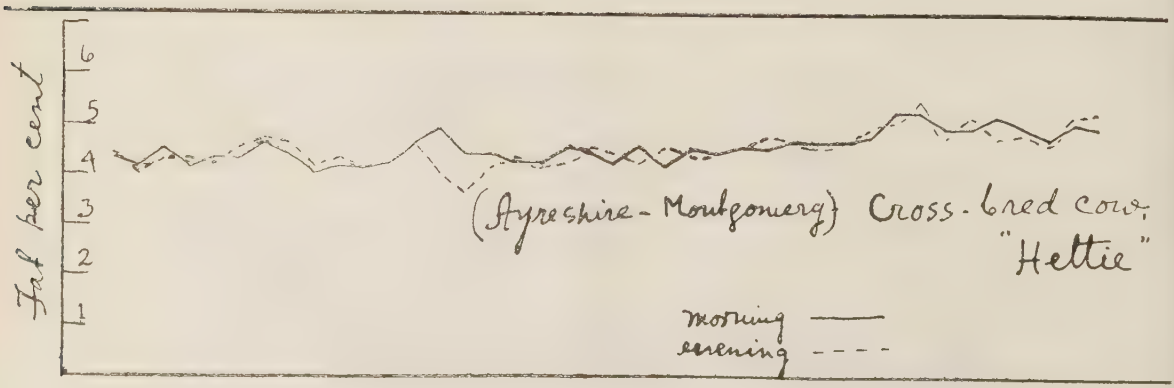
quality by Nos. 7, 5, and 6. The remainder were unsuitable for cigarette manufacture.

The samples are now being examined for their nicotine, sugar, and starch contents in order to study the changes which have occurred.

Variations in the fat content of milk of selected cows. Samples of the milk of three Montgomery and three cross-bred cows have been examined twice daily for the fat content throughout the full period of lactation. The data obtained confirm the conclusion previously drawn that there is a gradual rise in the fat content during the lactation period.

The fat content of the milk of two Montgomery cows was observed to reach a maximum of 9·0 and 9·2 per cent. respectively, and one of the cross-bred cows gave a maximum of 8·6 per cent.

The records in the form of weekly averages of the cross-bred cow Hettie and the Montgomery cow Chandra are given below. The morning's milk is represented by a solid line and the evening's milk by a broken line.



Lime requirement of acid soils. Mr Das is making a comparative examination of the numerous methods which have been propounded for the estimation of the lime requirement of acid soils in order ultimately to find out a method which can be correlated with agricultural practice.

Typical acids soils—both laterite and humus soils—have been obtained from Burma, Tocklai, Jorhat, Karimganj, Dacca and Ramgarh and tested by various methods, *viz.*, (1) Truog's qualitative method with barium chloride and zinc sulphide mixture, (2) Hopkin's method of extraction with normal potassium nitrate, and (3) Hutchinson and MacLennan's method of treatment with $\frac{N}{50}$ calcium bicarbonate with the following results :—

Acidity in increasing order by Truog's test :—

Burma soil < Ramgarh < Jorhat < Dacca < Karimganj < Tocklai

Method of test	Lime requirement per million parts soil					
	Burma soil	Jorhat soil	Ramgarh soil	Dacca soil	Karimganj soil	Tocklai soil
Hopkins	94·5	126	164·5	175	567	880
Hutchinson and MacLennan .	588	532	896	672	840	808

It is evident that there is some agreement between Truog's and Hopkin's tests probably due to the fact that in both cases extraction is made with a salt solution, whereas there is no agreement with Hutchinson and MacLennan method. This work is still in progress.

Investigations conducted by the Physical Chemist. Mechanical analysis of soils. The pipette method of mechanical analysis has been found to give results closely agreeing with the beaker method, and is very much quicker than the latter.

Some minor modifications in the method as described by Robinson [1] have proved useful ; for instance, suction by mouth has been replaced by mechanical suction ; and a pipette bent at right angle at the tip has been substituted for the one ordinarily used.

A comparative study of the methods of preparation of the soil for mechanical analysis has revealed the interesting fact that preliminary treatment with hydrogen peroxide (New British Official Method) or heating with dilute hydrocloride acid (Hissink's method) is not necessary to get the maximum dispersion. Treatment with $\frac{N}{20}$ HCl (cold) until the soil is free from calcium ions and subsequent shaking with dilute ammonia is quite sufficient for the purpose.

[1] Robinson. *Jour. Agri. Sci.*, 12 (1922), p. 306.

Base exchange. The following method has proved very useful for determining the saturation capacity of a soil for bases (base exchange capacity) :—10-20 grm. of the soil is placed in a tall beaker and sufficient $\frac{N}{59}$ HCl added to decompose all the carbonates ; 200-500 c.c. of $\frac{N}{20}$ HCl are then added and the mixure left overnight with frequent stirring. Next morning the soil is transferred to a filter paper and continuously washed with $\frac{N}{20}$ HCl *until the filtrate shows no reaction for Ca ions.* It is then washed with $\frac{N}{5}$ Ba Cl_2 solution *until the filtrate is neutral.* This is followed by washing with water *until the filtrate is free from Ba ions.* Finally, it is washed with $\frac{N}{50}$ HCl again until no more Ba comes in the filtrate. This filtrate is collected and Ba determined in the whole or in an aliquot portion, and the base exchange capacity expressed in milli-equivalents of Ba per 100 grm. of dry soil.

The factor, if determined as above, is found to be a characteristic constant for the soil which is not affected by slight alterations in the working conditions. For instance, it is not necessary to adhere strictly to the strengths of solutions mentioned above ; nor is the method susceptible to change of temperature or the amount of washing with each solution ; air drying or oven drying of the soil has no effect ; even treatment with hydrogen peroxide which is known to decompose all the organic matter in the soil seems only to have some slight effect on base exchange capacity. It thus appears to represent a definite factor for soil characterization, which may prove capable of correlation with other soil factors.

Unfree water in soils. Bouyoucos and his co-workers in a series of interesting papers[1] have put forward the contention that a part of the water in the soil is so bound up that it does not function as a solvent for salts, etc.

The evidence in favour of the above hypothesis though supported by numerous experiments, is still indirect, and an attempt was made to obtain direct evidence by shaking sugar solutions of varying concentrations with dry soil and determining any change in concentration by the freezing point depression.

The results show that up to a certain concentration (from 4-9 per cent. depending on the nature of the soil) the soil is able to absorb the sugar solution as such ; and as in the soil solution we meet with much lower concentrations it is extremely unlikely that any " unfree water " exists in the soil.

Measurement of the degree of unsaturation of the soil by inversion of sucrose. A soil is said to be unsaturated when it contains hydrogen ions in the exchange complex, which are replaceable by metallic ions. These hydrogen ions are assumed to be the cause of soil acidity and lime

[1] *Michigan Agri. Coll. Expt. Sta. Bull.* 24 (1915), 31 (1916), 36 (1917), 37 (1917), 42 (1918). Also, in *Jour. Agri. Res.*, 8 (1917), p. 195 ; 15 (1918), p. 331.

requirement, and therefore their determination is of considerable importance in the studies of such problems.

The amount of sucrose inverted under a prescribed set of conditions seems to bear a close relatiosnhip to the amount of replaceable hydrogen, or the degree of unsaturation of the soil. The method is simple, rapid and fairly accurate, and is likely to give a good picture of soil acidity and related phenomena.

VI. Programme of work for 1927-28.

A. Imperial Agricultural Chemist.

(1) The effect of manures on the quality of sugarcane juice and the *gur* produced therefrom.

(2) The composition of crops as affected by manurial treatment.

(3) Variation in the composition of milk.

(4) The detection of adulterants in butter and *ghee*.

(5) A study of the changes occurring in tobacco leaf under various methods of curing.

(6) A survey of the methods proposed for the determination of the lime requirements of soils.

(7) The employment of certain metallic electrodes for the field estimation of soil acidity.

(8) An attempt to determine the normal variations in the composition of sugarcane juice from canes grown under identical field conditions.

(9) Analytical work for other Sections.

B. Physical Chemist.

(1) Continuation of the work on the inversion of sucrose by soils.

(2) Continuation of studies on base exchange in soils.

(3) Studies on the relation between the nature of replaceable bases and some physico-chemical properties of the soil.

(4) Studies in soil colloids.

(5) Investigations on the mechanism of water absorption in soil.

VII. Publications.

Harrison, W. H. . .	Report on the Progress of Agricultural Chemistry in India for the year 1926-27, for the Committee of the Privy Council for Scientific and Industrial Research, London.
Sen, J., and Amin, Bhailal M.	A Study of Absorption of Moisture by Soils, *Mem. Dept. Agri. India, Chem. Ser.*, Vol. VIII, No. 12.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(J. H. Walton, M.A., M.Sc.)

I. Administration.

I held charge of the Section throughout the year.

Mr. N. V. Joshi, First Assistant, was on leave on average pay for 8 days from 23rd October, 1926, and for 26 days from 5th April, 1927; Mr. C. S. Ram Ayyar, First Assistant, Industrial Branch, acted in place of Mr. N. V. Joshi.

Mr. S.V. Desai, Assistant to the Imperial Agricultural Bacteriologist, was on leave on average pay for 1 month and 3 days from 24th January, 1927. Mr. Harihar Prasad, Laboratory Assistant, acted in place of Mr. Desai.

II. Training.

Mr. M. R. Madhoke, B.Sc., post-graduate student, was under training during the year.

III. Soil Biology.

Nitrogen fixation. An extensive series of investigations on the fluctuations in the total nitrogen content of soils at Pusa was carried on throughout the year. Five plots of the permanent manurial experiment in the Punjab field were analysed for nitrate and total nitrogen to a depth of one foot every month. The samples of the top six inches of soil from each plot were incubated at 30° C. and the total nitrogen estimated again at the end of one and of two months, for comparison with the nitrogen content of the fresh samples. The nitrogen content in all the plots was highest in July, and lowest in October 1926. Except that the plots that were green-manured showed a sharp rise in nitrogen in December, followed by a fall in January, the fluctuations were not very great. From March to June 1927, there was a gradual rise in the nitrogen content of all the plots.

The greatest amounts of nitrogen were found in plot No. 16A (green manure and superphosphate). This was followed by plots No. 8A (superphosphate), and No. 3A (farmyard manure), approximately equal, then by No. 12A (green manure), and the lowest amounts were always found in plot No. 11A which received no manure.

The observations will be continued for the next year, to complete the two-year crop rotation practised in the plots.

A similar series of observations was carried on with one of the plots in the experimental area of this Section. From this plot, samples were taken every ten days. One-half of the plot was cropped and the other half left fallow. Except for two sudden increases, from 42 to 52 mg. nitrogen per 100 grm. soil in August 1926, and an almost equally rapid decrease to 43 mg. in September, and from 45 to 51 mg. in October followed by a decrease to 45 mg. ten days later, fluctuations were small and gradual. The cropped plot generally held about 2 mg. nitrogen per 100 grm. soil less than the fallow plot.

Four series of observations were also carried out on the irrigated land, growing maize and berseem, in the Simri and Chandman *dhab* areas. Very wide fluctuations in the nitrogen content of the plots were found. With the exception of one plot, on poor sandy soil, these lands contained about double the nitrogen content of the plots in the experimental areas.

Laboratory experiments on nitrogen fixation in Pusa soil with the addition of various phosphatic manures, carried on for six months, gave very irregular results. The samples with no addition of phosphatic manure fixed as much nitrogen as the others did. In a similar experiment with Chinsurah soil, all samples lost nitrogen.

Nitrification. Further experiments on nitrification, in continuation of those referred to in the report of this section for 1925-26, were carried out.

It was found that the " tolerance " of large quantities of ammonia (equivalent to 120 mg. nitrogen per 100 grm. soil), introduced as cake or as ammonium sulphate, and nitrification of this quantity of nitrogen, arose from the large numbers of nitrifying organisms introduced by the inoculum, and that nitrite-forming organisms were of no assistance. It was considered that nitrates might possibly be a more stable form of nitrogen in soil than either ammonia or nitrites. To four lots of soil were therefore added 120 mg. nitrogen in the forms of (1) oil-cake, (2) ammonium sulphate, (3) sodium nitrite, and (4) potassium nitrate. A fifth lot was kept as control. All soils were kept at 16 per cent. moisture content and incubated at 30° C. It was found that the nitrite nitrogen disappeared first, followed by the ammoniacal nitrogen.

	Mg. nitrogen as	Times of incubation					
		1st week	2nd week	3rd week	4th week	6th week	8th week
Control (No addition of nitrogen)	NH_3	4·20	1·68	1·68	2·52	2·52	6·72
	NO_2	0·39	0·00	0·00	0·00	0·00	0·00
	NO_3	0·00	3·75	Traces	4·50	4·50	3·60
120 mg. nitrogen added as cake	NH_3	39·96	51·24	46·20	42·00	25·20	18·48
	NO_2	Traces	0·00	0·00	1·17	7·29	2·92
	NO_3	0·00	0·00	0·00	3·00	3·00	3·00

	Mg. nitrogen as	Times of incubation					
		1st week	2nd week	3rd week	4th week	6th week	8th week
120 mg. nitrogen as ammonium sulphate.	NH_3	100·80	90·72	78·12	25·20	19·32	22·68
	NO_2	Trace	0·00	0·39	5·83	7·29	1·94
	NO_3	*Nil*	0·00	Trace	6·00	6·00	7·50
120 mg. nitrogen as sodium nitrite.	NH_3	8·40	5·04	10·92	4·20	6·72	7·56
	NO_2	8·75	2·43	4·86	4·86	3·89	1·94
	NO_3	9·00	9·00	12·00	9·00	12·00	6·00
120 mg. nitrogen as sodium nitrate.	NH_3	5·04	6·72	6·72	5·88	3·36	2·52
	NO_2	0·78	0·58	0·97	1·21	3·89	0·19
	NO_3	120·00	120·00	90·00	97·50	90·00	96·00

The results in the Table show that large quantities of nitrite or ammoniacal nitrogen are liable to be lost from the soil unless converted into nitrates by nitrifying bacteria.

Direct counts were made of the numbers of bacteria present in soils in which nitrification was proceeding, to see if any relation could be found between the numbers of bacteria and the amount of nitrification. It was found that where nitrification was going on, the number of organisms present was maintained at a high level for a longer period than in those cases where there was no nitrification.

Influence of fermentation on the nitrification of organic manures. The nitrification of the organic nitrogen of mustard cake had been found to proceed more rapidly after the cake had been fermented with soil and charcoal than when fresh cake was used. Experiments were therefore begun to see if similar composting had any influence on the nitrification of the nitrogen in *mahua* (*Bassia latifolia*) cake. The nitrification was examined in black cotton and Sihar soils from the Central Provinces as well as in Pusa soil.

In every soil most nitrate was recovered from the composts of cake, soil and charcoal or cake and charcoal, and in these composts there was also most ammoniacal nitrogen. The composts were used for manuring small plots of oats, and the yields of oats were highest in the plots manured with the cake fermented with soil and charcoal. Composts containing sulphur were too expensive to be profitable.

The cake-charcoal-soil compost is made by mixing 100 parts of cake, 25 of soil and 5 of charcoal, moistening with 65 parts of water and inoculating with a little watery extract of fresh cowdung. The heap is left alone except for the addition of water to make up losses of moisture, and is ready for application to the land after twelve weeks' fermentation.

Nitrification of calcium cyanamide. A series of experiments on the nitrification of calcium cyanamide in soils of different characters was

begun, and the nitrification of cyanamide compared with that of ammonium sulphate and of mustard cake. In the first set of experiments, the amount of nitrogen added was 30 mg. to 100 grm. soil. With most of the soils no or only little nitrification of the cyanamide was found, but cake and ammonium sulphate were nitrified readily.

The quantity of added nitrogen was therefore reduced to 5 mg. per 100 grm. soil, after which nitrification usually took place as readily with calcium cyanamide as the source of nitrogen as with ammonium sulphate. The soils in which nitrification was tested came from :— Pusa ; Cawnpore and Kalianpur (U.P.) ; Gujranwala and Sialkot (Punjab); Kalol (Bombay) ; Sihar and black cotton soil of the C. P. ; Ranchi, (Chota Nagpur) ; Chinsurah, (Bengal) ; Karimganj, (Sylhet).

The results obtained can be summarized as follows :—

(*a*) *Pusa soil.* No nitrification of cyanamide nitrogen added at the 30 mg. rate in 30 weeks. At the 5 mg. rate about one-quarter of the added nitrogen nitrified in eight weeks.

(*b*) *Cawnpore soil.* With nitrogen added at the 30 mg. rate, there was no nitrification of cyanamide in 16 weeks ; ammonium sulphate nitrified almost completely in ten weeks. At the 5 mg. rate, half the added nitrogen nitrified in two weeks and 70 per cent. in ten weeks.

(*c*) *Kalianpur soil.* At the 30 mg. rate, there was no nitrification of cyanamide in ten weeks, but half of the ammonium sulphate nitrified. At the 5 mg. rate, nitrification of cyanamide started in two weeks and about 60 per cent. was nitrified in ten weeks.

(*d*) *Gujranwala soil.* At the 30 mg. rate, there was no nitrification of cyanamide in eight weeks, but 77 per cent. of the ammonium sulphate nitrified. At the 5 mg. rate, nitrification of cyanamide had not started in seven weeks.

(*e*) *Sialkot soil.* At the 30 mg. rate, no nitrification of cyanamide in eight weeks, but 80 per cent. nitrification in two weeks with ammonium sulphate. At the 5 mg. rate, 70 per cent. nitrification of cyanamide in three weeks.

(*f*) *Kalol soil.* At the 30 mg. rate, no nitrification with cyanamide in 15 weeks. Vigorous nitrification took place between the 15th and 20th weeks, when more than half of the added nitrogen was nitrified. By the 24th week, nitrification of the cyanamide had equalled that of cake and exceeded that of ammonium sulphate. At the 5 mg. rate, there was complete nitrification of cyanamide nitrogen in two months.

(*g*) *Sihar soil.* At the 30 mg. rate, there was no nitrification of cyanamide nitrogen in eight weeks, in which time, half the ammonium sulphate was nitrified. Vigorous nitrification of

cyanamide started between the 8th and 10th weeks and was almost complete in 14 weeks.

(*h*) *Black cotton soil.* Little nitrification of cyanamide in 12 weeks.

(*i*) *Ranchi soils.* Upland soil. No nitrification of cyanamide at the 30 mg. rate in 18 weeks. 50 per cent. nitrification with cake and only 12 per cent. with ammonium sulphate. At the 5 mg. rate, 90 per cent. of the cyanamide nitrified in eight weeks.

Valley soil. At the 30 mg. rate, only traces of nitrification of cyanamide in 16 weeks, but 70 per cent. of ammonium sulphate nitrified. At the 5 mg. rate, 66 per cent. nitrification of the cyanamide in eight weeks.

Intermediate soil. At the 30 mg. rate nitrification *nil* with cyanamide, 37 per cent. with ammonium sulphate and 73 per cent. with cake. At the 5 mg. rate 60 per cent. of the cyanamide nitrified in four weeks.

(*j*) *Chinsurah soil.* At the 30 mg. rate, no nitrification of cyanamide after 24 weeks, when nitrification of cake and ammonium sulphate were at a maximum, but between the 24th and 30th weeks, 27 per cent. of the cyanamide nitrified. At the 5 mg. rate, 30 per cent. nitrification with cyanamide and 60 per cent. with cake and ammonium sulphate.

(*k*) *Karimganj soil.* No nitrification in six weeks with any of the three sources of nitrogen. Details for a longer period were not ready at the time of writing.

It is probable that the reason why, with the addition of calcium cyanamide at the rate of 30 mg. of nitrogen to 100 grm. soil, no nitrification takes place for many weeks, though it may take place readily when only one-sixth of this quantity of the cyanamide is added, is that calcium cyanamide contains some ingredient which prevents nitrification. Even with the heavier dose, ammonification takes place rapidly, but the change of this ammonia into nitrate is prevented until a substance which checks the activity of the nitrifying bacteria is destroyed. When a 5 mg. dose of nitrogen is added, the quantity of the harmful substance may be either so small as to exert slight influence on the nitrifying bacteria, or it may disappear rapidly.

To test this hypothesis, an experiment was started using two lots of Pusa soil, to each of which were added 30 mg. nitrogen per 100 grm. soil, to he first as cake, and to the second, half as cake and half as calcium cyanamide, After eleven weeks, the amounts of nitrate found per 100 grm. soil were 18 mg. in the first and 2·7 mg. in the second, and after 15 weeks, 21·6 mg. and 7·8 mg. respectively. The calcium cyanamide, therefore, appears to have prevented the nitrification of the cake.

Further experiments on the nitrification of calcium cyanamide will be carried on during the current year.

Carbon dioxide respiration in soils. The Ranchi soils used in the nitrification tests with calcium cyanamide were examined to determine the influence of lime and phosphoric acid on the amount of carbon dioxide given off by these soils. The soil moisture was made up to the optimum quantity. The amounts of carbon dioxide given off in six days is shown below in milligrams.

Type of soil	Treatment		
	Series I	Series II	Series III
	100 grm. soil +0·5 grm. extracted mustard cake	As I+0·5 grm. $CaCO_3$	As II + 0·2 grm. dipotassium phosphate
Upland	112	156	202
Intermediate	112	139	143
Valley	110	166	142

All the soils show a good response to the addition of lime and the Upland soil does so to phosphate also.

Cellulose decomposition. The study of the cellulose decomposing organisms and its symbiotic organism referred to in my report for 1925-26 was continued. The ratio of the amount of nitrogen used to the amount of cellulose decomposed was found to be 1:40 with one symbiotic organism and 1:50 with the other. Alcohol, acetic acid and butyric acid were found in the decomposition products, but no reducing sugars were detected. When starch was decomposed, alcohol, acetone, aldehyde, acetic, butyric and formic acids were produced.

From glucose the organisms produced alcohol, aldehyde, acetic, butyric and formic acids.

When grown with azotobacter, they stimulated the fixation of nitrogen with cellulose as the source of energy. About 15 to 16 mg. nitrogen were fixed for each gramme of cellulose consumed.

The soils of the five plots in the Punjab experimental area, the nitrogen contents of which were being examined, were tested with reference to their ability to ferment cellulose. Plot 16A (green manure and superphosphate) was far the most efficient, and plot 11 (no manure) was the least active. Cellulose destruction in the other three plots was approximately equal.

Imperviousness in soils. Further work was carried on with certain strains of bacteria causing imperviousness in sand beds associated with

the production of slime. When grown in soil both under laboratory conditions and on a larger scale in channels in the field, attempts at producing imperviousness were unsuccessful, probably owing to the destruction of the slime by the bacterial flora of the soil under the conditions of experiment.

Phosphate solubilization. In continuation of the work of the last year on the solubilization of the phosphoric acid of bonemeal, composts were prepared on a larger scale, to provide enough of the product for trials in the field.

The first compost of bonemeal, sulphur, sand and charcoal was inoculated with a liquid culture of sulphur-oxidizing organisms in January 1926, and other compost heaps Nos. 2 and 3 were inoculated with portions of the first in March and April 1927.

The percentages of soluble phosphate found in the three composts are given in the Table below.

——	Compost 1	Compost 2	Compost 3
At start	28·2	23·5	23·2
After 8 weeks . . .	39·5	43·5	..
After 10 weeks . . .	40·8	..	44·3
„ 16 „ . . .	43·8	64·2	Not yet determined.
„ 45 „ . . .	64·8	Not yet determined.	„

The first and second composts were used for small plot manurial trials on potatoes, oats, mustard, tobacco, chillies and onions at Pusa, and bonemeal and superphosphate were also used for comparison.

The superiority of the compost to ordinary bonemeal as a manure for mustard, oats and potatoes was well marked.

IV. Dairy Bacteriology.

Bacteriological examinations of the milk supplied by the Pusa farm were carried out during the year. Further evidence of the relation between the season of the year and the plate counts was obtained.

The rains of 1926 did not break until July and there was an immediate increase in the plate counts from an average of 11,100 in June to 25,000 and the counts remained high till November. Sanitary milk pails were introduced into the milking shed in place of the old open type during the cold weather of 1926-27, and it is doubtless due to their use that the plate counts from March to May 1927 were lower than in any of the

three previous years during which counts were made. In June there was heavy rain, and the counts, as usual, rose, but only to an average of 15,500, higher than that of 1926 when there was very little rain, but lower than that for 1924.

The equipment of the laboratory for work on milk has been improved by the recent purchase of a " Frigidaire " for use as a cold incubator. It was obtained too late in the year for much work to be done with it, but some preliminary work in June showed that the samples of milk tested remained quite good for two days, and were still fit for pasteurization at the end of four days, storing at a temperature of 48° to 50° F.

Three samples of sterilized milk were received from the Karnal dairy. These had gone bad on storing. One sample, that had been sterilized at 105° C. for 50 minutes, and had gone bad in four days, was almost completely peptonized when examined. The cause was undoubtedly defective sterilization, for the " milk " was full of spore-forming bacteria, and laboratory experiments in Pusa showed that 50 minutes heating at 105° C. was insufficient to destroy the spores. The defect in the other two samples could only have been due to contamination through leaks, through the joint of the lead seal fixing the lid to the body of the container. The time and temperatures of sterilization were found to be adequate for that purpose. The milk had curdled to produce a very acid curd, and from the curd was isolated the organism of the *B. bulgaricus* type which occurs in *dahi*, and produces much more acid than *Streptococcus lacticus*, the ordinary sour milk bacillus. The optimum growth temperature for the *bulgaricus* organism is about 37°-40° C·, and it grows much more slowly at temperatures of 20°-30°C. than the *Streptococcus*. In the cold weather of 1924-25, trouble had occurred in the Karnal dairy through the curdling of sterilized milk, and the organism responsible was found to be of the ordinary *Streptococcus lacticus* type. This curd was mildly acid, contrasted with the very high acidity of the curdled milk in the hot weather of 1926, which was too acid to be palatable.

It would appear therefore that the curdling of the sterilized milk both in 1924-25 and in 1926 was due to contamination from the air, and the type of curd produced depended on the temperature of the dairy, which in the first case favoured the growth of the *S. lacticus* type of organisms, and in the second that of the *bulgaricus* type.

In addition to the *bulgaricus* organism, a yeast was isolated from one of the samples of curdled milk ; this yeast produced 2 per cent. of alcohol in milk after six days' incubation.

Some work was done on the physiology of acid-formers in milk. It was observed that a yeast is always associated with the *bulgaricus* type of organism in *dahi*. When grown in pure culture, the latter organism dies in about twelve days, but when grown in a mixed culture

with the yeast, it survived for a month. Trials were therefore made to see if this yeast could be used for prolonging the life of *Streptococcus lacticus* cultures. It was found that pure cultures on agar died in one month, but when associated with the yeast, they lived for over four months.

V. Silage.

Bacteriological examinations of maize silage, prepared in the laboratory, were carried on in the last season.

Juice was extracted from the silage by pressure, plate and direct microscopic counts of the bacteria carried on, the total acidity and pH of the juice estimated. The first season's experiments showed:

(1) Twenty-four hours after ensiling, the plate cultures of juice contain a nearly pure culture of glistening, slimy colonies of a motile rod, which is not an acid-former.

(2) Acid-formers develop in the plate cultures of juice from silage three days old. They increase in numbers until the 9th to 12th day, and then there is a decrease. A few colonies of acid-formers were found in plates made from ten months old silage, at a dilution of 1 in 1,000.

(3) Titration and pH estimations showed increasing acidity during the first ten days, after which there was little change. There seemed to be no correlation between the pH and total titrable acidity.

(4) Bacterial counts by the direct microscopic method were always higher than the plate counts, but were not fixed multiple of these.

VI. Plant Diseases.

Betel-vine wilt. I visited diseased plantations of betel-vine in the neighbourhood of Calcutta in September 1926, and collected fresh material for further investigations on this subject.

Specimens were also handed over to the Imperial Mycologist who fortunately was able to isolate fungi from this material, which when inoculated in betel-vine plants produced the characteristic symptoms of the disease. As the Imperial Mycologist was able to trace the cause of the disease to a fungal attack, no further investigations were carried on in this Section.

Tobacco. Specimens of tobacco said to be suffering from "wild fire" were received from Chirala, South India. The appearance of the specimens, both whole and in microtome sections, agreed with the description of "wild fire," but the specimens were not received in good

enough condition to isolate the specific organism which causes the disease, and it was too late in the season to carry out more work.

Citrus. Citrus canker was identified in specimens received from Assam.

Areca-palm. I visited Sylhet to investigate the disease of areca-palms in that district. Many strains of bacteria were isolated from diseased specimens, but much further work will have to be done to ascertain the true cause of the disease, and this cannot be done conveniently at Pusa where the climate or soil does not seem to encourage the growth of areca-palms.

Onions. Two enquiries were received from the East Indian Railway concerning the nature and cause of rotting of onions in transit by rail, and all the available information on this subject was given.

The problems connected with the transport and storage of perishable commodities such as fruit and market garden produce are of great importance, to both the dealers in, and the carriers of, such commodities and the results to be obtained from a well organized attack on these problems, conducted by a whole-time staff, should fully justify the cost.

VII. E. C.

The usual supplies of E. C. were provided during the year. The graphode cells continued to give a concentration of only 1·7 to 1·8 per cent. available chlorine, while platinum wire cells gave over two per cent.

VIII. Miscellaneous.

Memoranda on Agricultural Bacteriology and the work of the Section were prepared for the Royal Commission on Agriculture and for the Imperial Conference on Co-ordination for Agricultural Research ; a written statement of evidence was supplied to the Royal Commission on Agriculture in India. A Summary of Progress of Research in Agricultural Bacteriology was prepared for inclusion in the Annual Report of the Committee of the Privy Council for Scientific and Industrial Research.

IX. Programme of work for 1927-28.

Work will be done on the following subjects :—

1. Soil nitrogen.
2. Nitrification of calcium cyanamide and of organic manures.
3. Bacteriology of silage.
4. Dairy bacteriology.

X. Publications.

Walton, J. H. . .	Seasonal Variation in the Germ Content of Milk at Pusa. (*Pusa Agri. Res. Inst. Bull.* 170.)
Ram Ayyar, C. S. .	A Bacterial Soft Rot of Garden Poppy. (*Mem. Dept. Agri. India, Bacteriological Series*, Vol. II, No. 2.)
Vyas, N. D. . .	Home-made Superphosphate and its effect on Potatoes. (*Agri. Jour. of India*, Vol. XXII, Pt. III, May 1927.)

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRae, M.A., D.Sc., F.L.S.)

I. Charge and Establishment.

Dr. W. McRae held charge of the Section throughout the year. The post of Second Imperial Mycologist was still held in abeyance.

II. Training.

Mr. S. N. Nanjundiah, B.Ag., a post-graduate student, admitted in November 1924, finished his course on 31st October, 1926.

Mr. G. I. Kovoor, B.Sc., a post-graduate student, was admitted in November 1925 and attended the course till 8th April, 1927, when he resigned in order to accept the post of Agricultural Officer, Andaman Islands.

Mr. Abdus Sattar, B.Sc., a post-graduate student sent by the Punjab Department of Agriculture, is still under training.

A student from the Institute of Animal Husbandry and Dairying, Bangalore, received a short course in diseases affecting cereal and fodder crops.

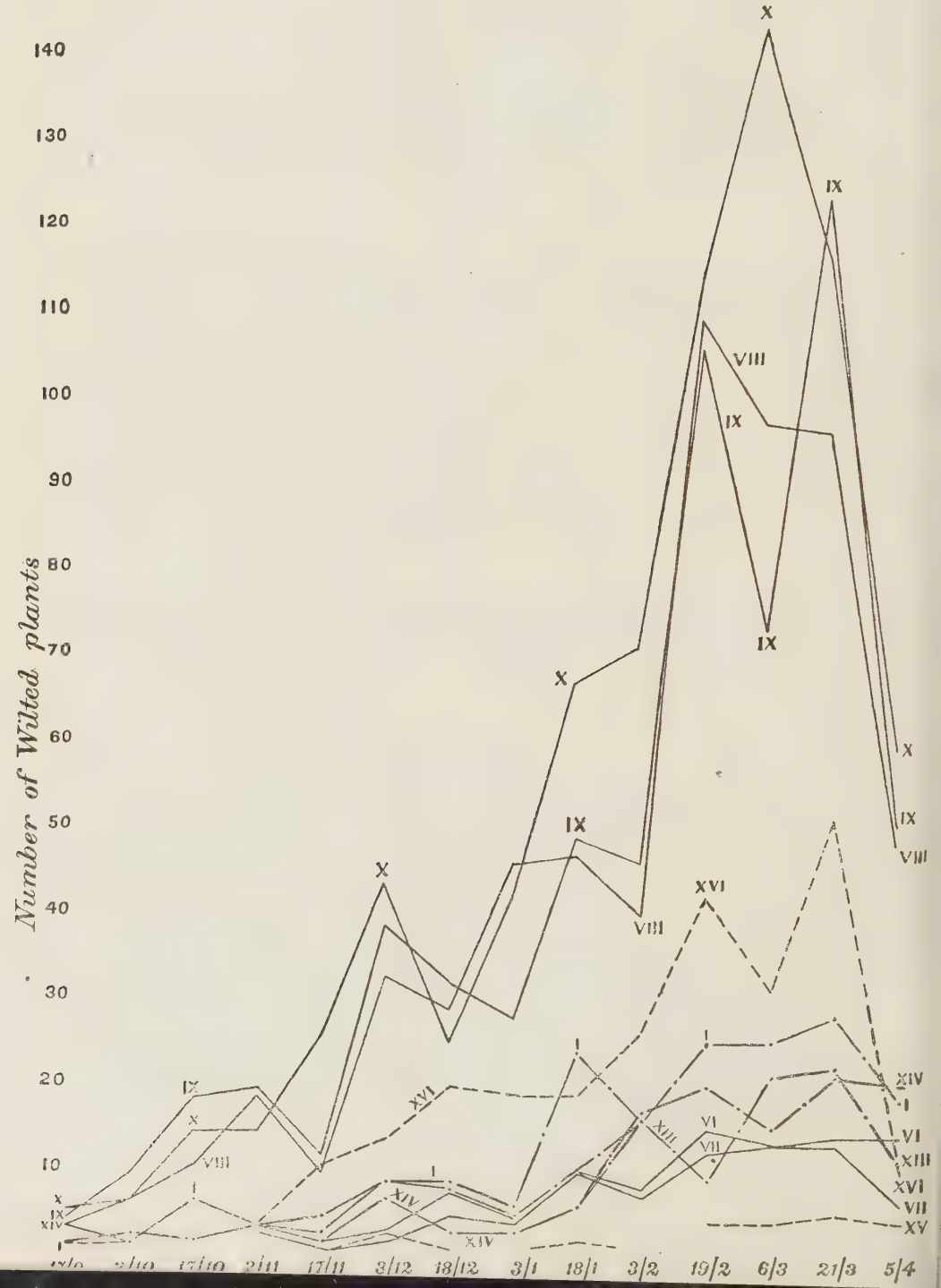
Mr. Kanhaya Lal, M.Sc., a post-graduate student of the Allahabad University, worked for a short time in the laboratory, and help was given in the identification of fungi on which he was working and in providing him with further material.

III. Diseases of Plants.

Wilt of rahar (*Cajanus indicus*). All the field experiments as mentioned in last year's report were carried on, and another experiment was laid down in six quarter-acre plots tested previously for the absence of disease in order to test the relative velocity of spread in land manured with superphosphate and in unmanured land.

The investigation which has for its object the isolation of a type of *rahar* which will prove resistant to wilt disease was continued in collaboration with the Imperial Economic Botanist on the lines laid down in the last Annual Report. The progress of the work is satisfactory, but a detailed report is not requir d this year. The number of wilted plants in the permanent manurial plots is as follows and they are shown graphically in the figure on p. 46.

Rahar, wilt, Punjab Permanent manurials, fortnightly deaths from wil
A. Series 1926-27.



Wilted rahar plants on the permanent manurial plots at Pusa.

Plot	Manures supplied per acre	A series No. of wilted plants	Percentage
I	No manure	166	7·1
II	Farmyard manure to supply 10 lb. nitrogen .	189	7·9
III	Farmyard manure to supply 20 lb. nitrogen .	140	5·5
IV	Farmyard manure to supply 30 lb. nitrogen .	303	11·6
V	Rape seed to supply 20 lb. nitrogen . .	137	6·2
VI	Sulphate of ammonia to supply 20 lb. nitrogen	88	3·8
VII	Sulphate of potash to supply K_2O as in farmyard manure No. III.	70	3·0
VIII	Superphosphate to supply P_2O_5 as in farmyard manure No. III.	582	22·1
IX	Sulphate of potash to supply K_2O as in No. III Superphosphate to supply P_2O_5 as in No. III .	598	23·6
X	Sulphate of potash to supply K_2O as in No. III Superphosphate to supply P_2O_5 as in No. III .	735	28·8
XIII	Deep-rooted leguminous crop (*rahar*) in cereal rotation.	107	5·0
XIV	One deep (*rahar*) and one shallow-rooted (peas) leguminous crop in the rotation.	111	5·0
XV	A leguminous crop and green-manure in the rotation.	16	0·7
XVI	Green-manure and superphosphate to supply P_2O_5 as in No. III.	240	10·8

Mosaic disease of sugarcane. (*a*) Distribution. In addition to the localities and varieties mentioned in last year's report, the following canes have been observed to have mosaic disease :—

Punjab. Gurdaspur—Co. 205, Co. 223, Co. 244, Co. 251, Co. 260, Co. 262, Co. 267, Co. 272, Co. 275, Co. 276, Co. 277, Co. 287, Co. 288.
Lyallpur—Co. 205, Co. 210, Co. 213, Co. 223.

Bihar. Sepaya—Co. 205, Co. 213, Co. 241, Co. 243.
Cuttack—Co. 213.

Madras. Cane-Breeding Station—Co. 210, Co. 296, Co. 305, Green Sport, Kalutai Boothan and nine crosses.

Assam. Jorhat—Co. 9, Co. 16, Co. 213, A1, A_2a, B. 147, D. 74, D. 625, J. 33A, J. 1547, Badila, Bogapura, Tanna, Striped Mauritius.
Karimganj—B. 147.

Bengal. Dacca—Co. 240, D. 74.

So far from all the 28 localities in India 47 Coimbatore seedling canes, nine crosses in the Coimbatore Cane-Breeding Station, 2 thin and 38 tropical varieties of cane have been reported to be infected by mosaic. The nine crosses and several of the Co. varities have been removed from cultivation.

(*b*) Sets of canes of Co. 205, Co. 213, Co. 232, Co. 250, Co. 281, Co. 287, Hemja and Red Mauritius whose leaves had mosaic markings reproduced the markings on the new plants.

(*c*) Sets cut from all positions of an infected cane produced plants with mosaic.

(*d*) The cell-contents of mosaic leaves were crushed out of the leaves, then placed on leaves of healthy cane and pricked in with a sterile needle. Controls were arranged where sterile distilled water was pricked in instead of the cell contents.

—	No. of shoots	No. of shoots whose leaves produced mosaic	Interval (days) between infection and appearance of definite symptom
Leaf of Co. 213 to leaf of Co. 213	13	8	29
Leaf of Red-Mauritius to leaf of Co. 213	16	16	45
Leaf of Co. 213 to leaf sheath of Co. 213	16	8	36
Leaf of Hemja to leaf of Co. 213	16	0	..
Leaf of Red-Mauritius to maize	16	4	10
Leaf of Co. 213 to maize	10	3	10
Leaf of Co. 213 to maize	17	5	10
Leaf of Co. 205 to maize	4	2	9
Leaf of Co. 213 to leaf of—			
Eleusine coracana	5	0	..
Panicum frumentaceum	6	0	..
Leaf of Co. 232 to *Andropogon Sorghum*	4	1	21

In no case did the controls produce mosaic markings.

(*e*) To test whether infection takes place in the field a row of each of the varieties Co. 205, Co. 281, Co. 250, Co. 273, Co. 210, Co. 213, Co. 214, Co. 275, Co. 280, Co. 286, Co. 290, and Uba was grown alternately with a row of Co. 232 every plant of which had mosaic. Three plants of the first mentioned variety developed mosaic, five of the second and one each of the third and fourth. Again in an area of 22 cents of Co. 213 from mosaic-free cane grown alongside a similar area of mosaic Co. 213, fifteen plants became infected, while in 14 cents of Co. 287 in similar conditions twenty-two plants developed mosaic. All the non-mosaic sets had been carefully selected before planting, so there is no doubt about these cases of mosaic being due to new infection during the season. This shows that mosaic spread in the field and that it did so to a very small extent this season. These facts show that the disease behaves in the same way as that described in other countries, that it is transmissible by sets and by injection into the leaf and leaf-sheath, that it passes from one variety of cane to another and from cane to maize and

jowar (*Andropogon Sorghum*), and that natural infection occurs. The natural carrier has not yet been found by the entomologist.

(*f*) *Loss.* Two pairs of plots of each of Co. 213 and Co. 287 were laid down to test the loss due to mosaic, but the yields of stripped cane were so near each other as to show that in these plots there was no loss from mosaic. The number and the size of the plots were limited by the amount of mosaic cane of these two varieties available in Pusa at the time of planting, and it is not claimed that the results are significant on a large scale. An analysis of samples of Co. 213 from these plots by the Imperial Agricultural Chemist showed that the difference in sucrose was so extremely small as to have no significance.

(*g*) *Deterioration.* A small amount of Red-Mauritius grown in Pusa from a very highly infected block in Sabour had every cane fully infected and the canes were only about 3 to 4 feet in length, while several other varieties of cane in the same plot were from 6 to 8 feet in length. This block of cane in Sabour was fully infected and short in stature. It had been unsatisfactory for several years and was discarded. It is likely that this is a case of deterioration due to mosaic of several years standing.

(*h*) Information regarding the germination of mosaic and non-mosaic sets and the rate at which mosaic mottling appears on plants that have grown from mosaic sets is furnished by the records of plot No. 9 and Gonhri plot. The former was irrigated, while the latter was not. The non-mosaic sets were carefully selected from healthy cane and are definitely known to have been free from mosaic for from two to four years. The mosaic sets were taken from canes with distinctly mottled leaves.

Field		Variety of cane	Total length of line	No. of sets planted	No. of eyes	No. of shoots	Percentage of shoots to eyes	No. of recognisable mosaic shoots	Percentage of mosaic shoots to shoots	No. of recognisable mosaic shoots	Percentage of mosaic shoots to shoots
								On 30th	April	On 10th	June
Gonhri Plot	Non-mosaic	Co. 213	1,158	1,475	4,425	1,432	32	0	..	0	..
	Mosaic	Co. 213	1,158	1,570	4,710	1,139	24	853	75	966	90
	Non-mosaic	Co. 213	78	84	252	111	44	0	..	0	..
No. 9 Plot	Mosaic	Co. 213	234	243	729	225	31	185	82	215	98
	Mosaic	Co. 287	78	93	279	83	30	82	99	83	100
	Mosaic	Co. 232	78	87	261	65	22	61	94	65	100
	Mosaic	Co. 205	78	75	225	36	15	28	50	50	90

The number of shoots that germinate and come above ground is small compared with the number of buds in the sets planted. In healthy Co. 213 it is 44 per cent. on irrigated land and 32 on unirrigated land. The Government Sugarcane Expert found from observations in the varietal plots in the Cane-Breeding Station at Coimbatore that in 44 Coimbatore seedlings the percentage of germination in the central buds was 64 and in the end buds 42. This would correspond to a germination of 49 per cent. in the field where three-bud sets were planted. As the fields in the Cane-Breeding Station are irrigated, the conditions correspond to those in the irrigated plot at Pusa, and the percentage germination in the two places, *viz.*, 49 and 44, are comparatively near. That the germination in the unirrigated field, *viz.*, 32 per cent., is somewhat lower is to be expected as the miosture content of the soil is much less. The percentage germination in sets from mosaic cane is lower by 13 per cent. in the irrigated and by 8 per cent. in the unirrigated land. The germination of mosaic Co. 287, Co. 232 and Co. 205 is also low, remarkably so in the last variety. As there is no cane of these three varieties that is so definitely known to be free from mosaic as that of Co. 213 under experiment, the relative difference between mosaic and non-mosaic cane cannot be found with accuracy this year. These data especially with regard to Co. 213 indicate that there is a possible loss through lower germination in mosaic cane. These two plots were planted from the 10th of February, 1927 onwards. At the end of April the number of shoots of Co. 213 that originated from mosaic sets and on which mosaic mottling was clearly recognizable on their leaves was 82 per cent. in the irrigated land, 75 per cent. in the unirrigated land, while on the 10th of June the percentage was 98 and 90 respectively. Mosaic in Co. 287 and Co. 232 showed up more quickly and by the 10th of June in every plant its presence was visible. In Co. 205, however, symptoms appeared much more slowly. This has a bearing on roguing. To be a practical method of dealing with the disease, roguing should be done as few times as possible in order to keep down expense, and yet it should be efficacious in reducing the disease substantially. A controlling factor is the spread of the disease. On the 24th June 8 plants or 7 per cent. in the non-mosaic line of Co. 213 in No. 9 plot had mosaic mottling in their leaves and on 26th June 5 plants or 0·3 per cent. in the non-mosaic Co. 213 in Gonhri plot also had it. In plot No. 9 every alternate line is mosaic material, so the non-mosaic plants are in a good position to become infected. The non-mosaic plants are from cane that has been observed to be free from mosaic for four seasons. In the Gonhri plot the non-mosaic cane is grown alongside the mosaic cane. The former was taken from plants that showed no signs of mottling on their leaves for two seasons. Hence these mosaic plants in the non-mosaic lines had been infected this season sometime after planting.

The carrier was not observed and the exact time of infection is not known. However, in the experiments of 1926 the interval between pricking in the virus and the appearance of mosaic mottling on the leaf varied from 29 to 45 days. Thus it is possible that the infection of these plants in the Gonhri and No. 9 plots took place as early as the 10th of May. Roguing should accordingly be done before this date, say, on the 1st May. Then 75 per cent. of the mosaic plants of Co. 213 in estate condition will have become visible and removeable before spread begins. By the 10th of June, just before the monsoon is expected to arrive, another 15 per cent. will be visible *plus* 0·3 per cent. of spread. Whether this is the sum total of the spread can only be seen from the further behaviour of the plants in these plots.

(*i*) *Chlorophyll estimation in mosaic and non-mosaic sugarcane leaves.* From equal areas of leaves from mosaic and non-mosaic sugarcane the chlorophyll was extracted in 90 per cent. alcohol and the depth of the tint of the chlorophyll extract was measured by Duboscq's Colorimeter. It was found that the tissues under the markings of mosaic leaves of Co. 213 had only 59 per cent. of chlorophyll as compared with a non-mosaic leaf and variations are from 39—84 per cent. Further work on this line is in progress.

Hence considering the lack of loss of tonnage this year it would appear that the amount of chlorophyll in the leaves is not a controlling factor in the production of carbohydrates.

(*j*) A marking on the leaves of plantain and bamboo somewhat like that of mosaic on sugarcane is under investigation.

Streak disease of sugarcane. Six sets from a cane of Uba variety showing streak disease were planted. Five germinated and all the shoots in these plants showed typical streak markings. Though our experiments in transmitting the disease have not been successful it is most likely due to error in technique, for the symptoms of the disease are typically those of the disease as described in Natal.

Wilt disease of Cajanus, cotton and sesamum. The soil in which young plants of *Cajanus indicus, sesamum indicum* and cotton were growing was infected with strains of *Fusarium vasinfectum* from *Cajanus* and cotton, but only the *Cajanus* plants became infected with the strain from *Cajanus*. This experiment will be repeated on a larger scale and all the three strains of *Fusarium vasinfectum* will be used.

Piper betel. In the deltaic regions of the Ganges, Brahmaputra and Padma rivers in Bengal great loss has been caused during the last few years in betel-vine cultivation by a disease whose most obvious symptom is a sudden wilting of the vines. Near the ground level the stem darkens, becomes brown, shrinks, softens, and sometimes bursts open exposing the fibres. The stem breaks readily at the nodes within the discoloured

area. The incidence of the disease varies considerably within the affected area. In some villages wholesale havoc is caused, while in most others a more or less heavy toll of vines is taken. The total loss probably runs into several lakhs of rupees a year. The disease becomes very active about the middle of July and continues till the end of September when it abates considerably. During the rest of the year deaths occur persistently in small numbers. Several fungi, the most common of which are the *Colletotrichum* and *Glœosporium* stages of *Glomerella cingulata*, have been isolated at various times but have proved to be saprophytic, their role being to help on the rot once it is started. However, the parasitism of three fungi has been established, a species of *Phytophthora*, *Rhizoctonia solani* and *Sclerotium Rolfsii*. They all attack that part of the stem that is underground and a few inches up the aerial stem. Sufficient detailed examination of the infected area has not been made to enable an exact estimate to be made of the relative importance of the part each fungus plays, but present observations indicate that it is most probable that the *Phytophthora* is the active agent during the monsoon, the *Rhizoctonia* in the cold weather and the *Sclerotium* in the hot weather. The *Phytophthora* is like that described by Thomson [1] in Malay and Dastur [2] in the Central Provinces. Close touch is being kept with the Economic Botanist and the Director of Agriculture, Bengal, in carrying out experiments in several places with a view to devise a method of overcoming the disease, keeping in mind the possibilities of changes in methods of cultivation and propagation and of spraying.

Cinchona. For various reasons the work on cinchona was held in abeyance, but towards the end of the year it was begun again. It has been found extremely difficult to establish plants for experiment in Pusa and the cinchona plantations are difficult of access.

Gram wilt. The study of resistance to wilt in 25 types of gram (*Cicer arietinum*) was continued with results similar to those of last year. Three of the eight types that failed to become wilted last year have shown wilt this year, so that in two years' trials, Types 15, 16, 21, 23 and 24 have remained free from wilt. This year too wilt appeared only in pots containing soil from around plants that wilted in the previous year. The strain of *Fusarium* with which we are working does not seem to be able to cause wilt. Two other strains have been isolated this year and work will be concentrated on this aspect of the problem.

Linseed wilt. The study of resistance to wilt which is caused by *Fusarium lini* Boll was continued as in last year's report. Only one of the sixteen types of linseed tried last year did not show some plants to

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Agri. Jour. India, XXI, p. 104, 1926.

[1] Thompson, A. A disease of betel vine caused by a species of *Phytophthora*. The *Malayan Agri. Jour.*, XIV, 1926.

[2] Dastur, J. F. A short note on the Foot-rot Disease of *Pan* in the Central Provinces. *Agri. Jour. of India*, XXII, 1927.

be wilted, but this year that type had 17 out of 62 plants wilted in last year's infected soil and 2 out of 25 in soil to which a culture of the fungus was added at the time of sowing. All the other fifteen types showed wilt though not always to the same extent as last year. So far only the type from Sabour has shown marked resistance to wilt. Wilted plants developed in soil that was infected with a culture at the time of sowing and also when the plants were four inches high.

Physoderma Zeae-Maydis was in great abundance during the monsoon of 1926 on all the maize on the farm and was fairly common in the fields outside. The sporangia failed to germinate though persistent attempts were made to induce germination by placing them alone and on the leaves in various constant temperatures, gradually and suddenly varying temperatures, various light intensities, various humidities and in an atmosphere with various concentrations of ether. Several infection experiments were tried with no results. During the monsoon of 1927 *Physoderma* was rare on the farm, but was fairly common on fields in the district.

Last year ten per cent. of the maize crop on the farm was attacked by *Sclerospora Maydis*. The diseased plants were rogued in July and fed to stock. The manure from one bullock fed on diseased plants only, for a week was conserved and used in a plot of maize this year. The seed was steeped in two per cent. formalin for twenty minutes before being sown. In this plot no plant had *Sclerospora Maydis*. On the farm where seed was not treated with formalin there is about 0·5 per cent. of infection over the whole crop so that rouging alone has reduced the disease considerably. This disease is confined to the farm and is never met with in the fields around Pusa.

All the varieties of barley in Pusa were very severely attacked by *Helminthosporium sativum*.

From dying cotton seedlings in Pusa, a *Phytophthora* was isolated and also from rotting fruits of guava. Both are morphologically similar to *Phytophthora parasitica*. The former fungus infected castor and sesamum seedlings with difficulty, while the latter attacked them readily.

Four hundred sporangia of each of *Phytophthora Meadii*, *Ph. Faberi*, and *Ph. palmivora* grown on oat-meal agar in the same conditions were measured. The average measurements are *Ph. Meadii* $27 \times 20 \mu$, *Ph. Faberi* 46×31 μ and *Ph. palmivora* 55×33 μ. Mixed cultures of pairs were grown in petri dishes in glucose agar, but no oospores were produced, similarly in liquid culture where, however, chlamydospores were produced in abundance.

From dying chilli seedlings in Pusa *Pythium aphanidermatum* was isolated and proved to be parasitic on chilli seedlings though not on grown plants. It did a considerable amount of damage in the seedling stage. This fungus is common in Pusa on various cucurbits, papaya and potatoes.

Sterility of rice grains. At Tamenglong in Manipur State the experimental cultivation of the varieties Manipuri and Gurkhali entirley failed as no grain was found though the plants looked healthy. The roots and shoots had a most copious mycelium of a *Fusarium.* The fungus was isolated and infection experiments with local rice showed that it was capable of killing seedlings and of producing sterile grains in those plants that survived. The same fungus was recovered from these mature plants. Further work is proceeding. A similar disease has been received from Gurdaspur and Lyallpur in the Punjab and it has been found in isolated patches in various villages around Pusa.

Smut on Kodra (*Sorosporium Paspali* McAlp on *Paspalum scrobiculatum*). The life-history was studied by a post-graduate student who found that during the first four months 2 per cent. of spores germinated and that the percentage gradually increased till at nine months it was 90 per cent. He found that 0·1 per cent. of copper sulphate solution for ten minutes will kill spores, but that it requires 0·5 per cent. for ten minutes to kill all the spores in a spore ball, and that concentrations up to 4 per cent. do not affect the germination of *kodra* seeds. A suitable concentration for field work is under experiment and a method of dusting is being tried.

IV. Systematic Work.

Eighty Indian specimens from new localities were added to the herbarium. A large collection of specimens was brought by the staff from the Andaman Islands. From the collection it was found that the various diseases on coconut palms, *Citrus*, rubber, coffee, tea, mango, jack-fruit are allied to species on these hosts in Burma and Peninsular India and the data collected are a valuable addition to the herbarium. A specimen of truffles received from Shillong was identified by the Imperial Bureau of Mycology, London, as *Sclerangium polirrhizon* (Gmel) Lev. This is the first occasion it has been reported from India and being of edible nature as reported its find is of interest. A rust on the leaves of onion was found at Lyallpur for the first time in India. It resembles *Puccinia porri* Saw. very closely. Accidiospores and telentospores were found.

A collection of Indian *Asterinas* and *Meliolas* was determined by Dr. Ruth Ryan of Rosary College, River Forest, Illinois, and Prof. F. L. Stevens, University of Illinois, Urbana, Illinois, U. S. A., respectively. The majority of the species are new and the report is in the press.

Specimens of local crop diseases were supplied to the student from the Allahabad University and a large collection brought by him from that locality was determined. A collection of specimens was supplied

to (1) Professor of Botany, Carmichael Medical College, Calcutta; (2) Mycological Assistant, Dacca; (3) Professor of Botany, Agra College; (4) Professor of Botany, Punjab University; (5) Principal, Islamia College, Peshawar; (6) Faculty of Agriculture, University of Sydney, Australia; (7) College of Agriculture, University of the Philippines, and (8) the Mycologist, Ceylon. Besides, on request, cultures of fungi were supplied to various mycologists in other countries.

V. Programme of work for 1927-28.

1. *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The following crop diseases will receive special attention :—

(*a*) Diseases of cereals.
(*b*) Diseases of sugarcane.
(*c*) Diseases of *rahar*.
(*d*) Diseases of gram and linseed.
(*e*) Diseases of betel-vine (*pan*).
(*f*) Diseases of cinchona.

2. *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

3. *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VI. Publications.

McRae, W. . . Report on Mycology, 1926-27, for the Committee of the Privy Council for Scientific and Industrial Research.

Mitra, M., and Subramaniam, L. S. . . Fruit-rot Disease of Cultivated Cucurbitaceae caused by *Pythium aphanidermatum* (Eds.) Fitz. *Mem. Dept. Agri., India, Bot. Series*, Vol. XV, No. III. (*In the press.*)

Stevens, F. L., and Ryan, R. . *Asterina* spp. from India, determined by Dr. Ruth Ryan and *Meliola* spp. from India and one from Malay, determined by Prof. F. L. Stevens. *Mem. Dept. Agri., India, Bot. Series*, Vol. XV, No. V. (*In the press.*)

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

Mr. M. Afzal Husain held charge of the Section from 1st July until my return from leave on 16th November 1926.

Mr. P. V. Isaac, Second Entomologist (Dipterist), was on leave from 1st July until 9th October 1926 and again from 9th to 18th April 1927.

Rai Bahadur C. S. Misra, First Assistant, whose services had been lent to the Indian Lac Association, reverted to his appointment at Pusa from 22nd April 1927.

Mr. G. R. Dutt, Personal Assistant, acted as First Assistant during the absence of Rai Bahadur C. S. Misra. He also held charge of the Second Entomologist's duties during the absence of the latter officer on leave from 1st July to 9th October 1926.

Mr. S. K. Sen, Assistant, was relieved on 29th August 1926 to proceed on leave prior to joining a new appointment at Muktesar. Mr. Sen has done excellent work during the sixteen years that he has been an Entomological Assistant at Pusa and his departure, to take a better appointment elsewhere, is a decided loss to the Entomological Section.

During the year, one Assistant left to join the Punjab Agricultural College, while another has been selected for an appointment at the Forest Research Institute. These transfers of trained Assistants, combined with the absence of two others on long leave, has given a considerable set-back to the efficiency of the Section.

II. Training.

(1) Mr. R. N. Mookerjee, M.Sc., who was admitted last year as a short course student in Systematic Entomology, finished his training on 6th August 1926.

(2) Mr. V. P. Varde, short course student, was under training from 6th May to 30th June 1927.

(3) Mr. Munwar-uddin, Artist of the Agricultural College, Lyallpur, was under training from 5th January to 30th March 1927 (3 months).

(4) Mr. Pashupati Roy, student deputed by the Department of Agriculture, Bengal, for training in Lac, was admitted on 1st June 1927 and was under training at the close of the year.

III. Insect Pests.

Sugarcane. At the instance of the Imperial Mycologist, experiments were started with the following sucking insects, *viz.*

(1) *Pyrilla* spp.

(2) *Assamia* (*Phenice*) *moesta.*

(3) *Pseudococcus* sp.

(4) Aphididæ,

to ascertain which, if any, of them may be responsible for the spread of Mosaic Disease at Pusa. The insects were sleeved for four weeks on diseased plants selected by the Mycological Section ; they were then removed and sleeved for a period of from four to eight weeks upon healthy plants, which, however, showed no signs of the disease. These were harvested, cut into setts and replanted, but even the new plants showed no sign of Mosaic.

Whilst examining cane stubble for hibernating borers, an Aphidid was found on cane roots at Pusa in December 1926. This has been identified as *Geoica spatulata*, Theobald, originally described (and hitherto only known) from Egypt, where it has been found on various Gramineæ.

A new cane-borer was reported in the Punjab and was investigated by an Assistant sent from Pusa, but so far no moths have been received in a condition fit for examination.

Work on cane-borers was continued at Pusa, but did not bring to light any borers not known previously during the continuous search during the last ten years.

Several requests for field-examination of cane for borers were met during the year. So far as can be judged at present, the main recommendations which can be made at present (apart from agricultural practices, such as clean cultivation—including prompt removal and destruction of stubble and avoidance of ratoon crops—early planting, and careful selection of setts) for the direct control of borers consist of (1) spraying the young crop with a stomach-poison to kill off the young borers whilst feeding on the tender leaves before boring into the stem and (2) collection of the egg-masses. The former method is generally only practicable in small areas where the work can be properly supervised and repeated as necessary ; the latter method mainly resolves itself into one of cost. Where cheap labour is available, as in most parts of Bihar, it will usually pay to collect egg-masses by hand.

The various kinds of Borers which are known to attack sugarcane in India were dealt with in two papers which appeared in the Reports of the Third and Fourth Entomological Meetings.[1] At that time, however, it was impracticable to give names to many of the insects dealt with and of those which were named many of the names have proved

[1] Borers in Sugarcane, Rice, etc., by T. Bainbrigge Fletcher and C. C. Ghosh. (*Report of Third Entomological Meeting*, Vol. I, pp. 354-417 : 1920). Also issued as *Pusa Bulletin* No. 102.

Supplementary Observations on Borers in Sugarcane, Rice, etc., by C. C. Ghosh. (*Report of Fourth Entomological Meeting*, pp. 105-136 ; 1921). Also issued as *Pusa Bulletin* No. 134.

to have been wrongly applied. It may, therefore, be useful to give a revised list of the correct names, so far as known at present, of these Borers.

(1) The purple-coloured Zeuzerid Borer (C. S. 1805) (*Third Report*, Vol. I, p. 373, Plate 34, fig. 1) is an undescribed species of *Phragmatœcia* which is now named *Phragmatœcia purpureus*, n. sp., the specific name referring to the characteristic colour of the larva. (Plate I, fig. 1.)

(2) The violet-spotted Zeuzerid Borer (C. S. 1696 and C. S. 1857) (*Third Report*, Vol. I, p. 374, Plate 35, fig. 1) is now named *Phragmatœcia terebrifer*, n. sp., the specific name (Latin *terebra*, a gimlet) referring to the sharp, pointed snout of the pupa. (Plate I, fig. 2.)

(3) C. S. 1666 (*Third Report*, Vol. I, p. 377, Plate 38, fig. 1) is now named *Busseola sacchariphaga*, n. sp. (Plate II.)

(4) The Phycitid Borer (C. S. 1837 and C. S. 2060) (*Third Report*, Vol. I, p. 378, Plate 39, fig. 1 ; *Fourth Report*, pp. 120-121, Plate 19, fig. 1) is apparently *Saluria spurcella*, Ragonot.

(5) *Scirpophaga xanthogastrella* (*auriflua*) (*Third Report*, p. 381, Plate 41). The specific name *nivella*, Fabricius, has precedence.

(6) *Schœnobius bipunctifer*, Wlk. (*Third Report*, Vol. I, p. 383, Plate 43). The name, *Chilo incertellus*, Wlk. referred to in the footnote, is praeoccupied by *Chilo incertella*, Zincken, 1821 ; the name *bipunctifer* is therefore used for our species.

(7) *Chilo simplex*, Butler (*Third Report*, Vol. I, p. 385, Plates 45-47). I have examined the male type of Butler's *simplex*, from Formosa ; this type, in the British Museum collection, is in poor condition but seems to have the forewing narrower and duller fuscous and the hindwing whiter than in our common Indian Borer which has been identified hitherto as *simplex*. I conclude that our species is not *simplex* but it seems to answer to *zonellus*, Swinhoe, which name may be used for the present. It is curious that such an abundant species was not named earlier, and it is quite possible that some previous name may prove applicable. It may be added that specimens of larvae received from Japan and which are presumably those of the true *Chilo simplex*, Butler, do not agree with any of our Indian Borers as yet known to us.

(8) *Diatraea auricilia* (C. S. 1574) (*Third Report*, Vol. I, p. 387, Plate 48, Plate 49, fig. 1). This species is not the true *auricilia*, Dudgeon, as determined by examination of Dud-

geon's material in the British Museum. It is *Argyria sticticraspis*, Hampson (*A.M.N.H.* (9) III 449; March 1919), described from a female type from Coimbatore, with which *Argyria coniorta*, Hampson (*A.M.N.H.* (9) III 449; March 1919), described from a male type from Pusa and from another specimen from Sikkim (1800 feet), is identical. Fortunately, the female type of *sticticraspis* has been preserved with its pupa-case and can therefore be compared without doubt. This seems to be the commonest cane-borer in Madras; a series of cane-borers (larvae, pupæ and moths), recently sent for identification by the Government Entomologist, Madras, and coming from Coimbatore and Anakapalle, proved to consist of *Argyria sticticraspis* exclusively.

(9) *Diatraea* sp. (C. S. 1610) (*Third Report*, Vol. I, pp. 388-389, plates 52, 54 and 53, fig. 1), as noted in the footnote on p. 388, is *Argyria tumidicostalis*, Hampson (*A.M.N.H.* (9) III 449; 1919), which was described from a male from Pabna (not Patna). It may be noted here that *Chilo gemininotalis*, Hampson (*A.M.N.H.* (9) IV 59; August 1919) described from a female from Kanny Koory, in Cachar, is a synonym of *tumidicostalis*.

It may also be remarked here that the limits of the genera *Chilo*, *Diatraea* and *Argyria* still remain to be determined.

(10) *Diatraea* sp. (C. S. 1674.) (*Third Report*, Vol. I, pp. 389-390, Plates 55, 56.) This is the true *Diatraea auricilia*, Dudgeon, according to his type in the British Museum collection.

(11) The Rice Chilo (C. S. 1677). (*Third Report*, Vol. I, pp. 390-391, Plates 57, 58). This species is apparently undescribed and is now named *Chilo oryzae*, n. sp. (Plates III and IV.)

(12) *Chilo* sp. (C. S. 1769). (*Third Report*, Vol. I, p. 391, Plate 59, Plate 60, fig. 1.) This species is apparently undescribed and is now named *Diatraea kanra*, n. sp., the specific name being the vernacular name of one of its foodplants. (Plates V and VI, fig. 1.)

(13) *Diatraea* sp. (C. S. 1795). (*Third Report*, Vol. I, p. 391, Plate 60, figs. 2, 3.) This is another undescribed species, now named *Chilo saccharicola*, n. sp. (Plate VI, fig. 2.)

(14) *Chilo* sp. (C. S. 1831). (*Third Report*, Vol. I, p. 392, Plate 61, Plate 62, fig. 1.) Another undescribed species, now named *Diatraea batri*, n. sp. (Plates VIII, fig. 1 and IX, fig. 2.)

(15) *Chilo* sp. (C. S. 1835). (*Third Report*, Vol. I, p. 392, Plate 62, fig. 2, Plate 63.) This is still another undescribed species,

now named *Diatraea ikri*, n. sp. (Plates VII, fig. 2 VIII, fig. 2 and IX, fig. 1.)

(16) ? Pyralid Borer (*Third Report*, Vol. I, p. 393, Plate 64, fig. 1). *Chilo torrentellus* (*Fourth Report*, pp. 123-124, Plate 20). This is apparently *Diatraea torrentella*, Meyr., as previously identified. The British Museum contains specimens from Kangra and Madras.

(17) *Hypsotropa tenuinervella* (C. S. 1920 and 2016) (*Fourth Report*, p. 124, Plate 21). After examination of material placed under this name in the British Museum collection, I doubt whether our species is *tenuinervella*.

(18) *Crambus corticellus*, Hampson (*Fourth Report*, p. 125, Plate 22). The species referred to is more probably *Crambus atkinsoni*, Zeller, and not *corticellus*, Hampson, which latter is only known from the Khasi Hills.

Considerable work still remains to be done on the systematic side in connection with our Indian Cane-borers, but the foregoing notes will help to clear up some points in their identification.

The Mealy-bugs (*Pseudococcus* sp.) infesting sugarcane are at present under investigation.

The parasites of cane-borers have also been studied and some of these have been named for us by the Imperial Bureau of Entomology.

Sugarcane attacked by Mites was treated successfully by spraying with crude oil emulsion and flowers of sulphur.

Other crops. Numerous observations of the pests attacking Farm crops on the Pusa Estate have been continued, but only a few of these can be mentioned here.

In 1924-25 when experiments were conducted to control *Monophlebus octocaudata* var. *stebbingi* which attacks peach, plum and other fruit trees at Pusa, it was found that arresting the fertilized females on their downward march from the affected trees, by putting sticky bands round tree-trunks, and later on destroying them by spraying, etc., were very effective measures to control the pest. But these measures did not prove of much avail when tried against another closely allied species of *Monophlebus*, which is appreciably larger in size than *M. octocaudata* var. *stebbingi* and infests *Siris* (*Albizzia lebbek*) trees at Pusa. Consequently, two inquiries were instituted, first, to ascertain the causes of the failure of these remedial measures on *Siris* trees, and secondly to evolve a more suitable method to control this insect.

The *Siris* trees on which experiments were carried out were very old ones, with well-spread branches and a girth of about eighteen feet. It was observed that during the last week of April and early May, when strong west winds were blowing for nearly the whole day, a majority of

the fertilized females of *Monophlebus* dropped onto the ground from swinging branches, all around the trees. As a result of this, very few females were left on the trees, and these, of course, were captured near the sticky bands and killed. Those that fell on the ground, went under the soil and oviposited successfully. In the following year the trees were heavily infested again. It was therefore decided to interrupt the young bugs on hatching, from ascending the trees, by putting on them the sticky bands prepared in the laboratory. The result was extremely effective. Millions of bugs collected on, and below, the bands, and these were killed by dusting calcium cyanide on them. From 28th November 1926 to 16th January 1927, the sticky paste was renewed four times, and the dusting was done only twice.

A patent sticky-stuff, known as " Ostico," was supplied to us for trials against *Monophlebus*, by Messrs. Wilkinson, Heywood and Clark, Bombay. Bands prepared from this stuff and put on the trees in the month of May did not prove very successful, as the " Ostico " became very thin, on account of high temperature prevailing at the time. Another trial was given during the last cold weather, and the bands remained quite effective for two months, after which, dust, dry leaves, etc., which had settled on them, necessitated a second application. " Ostico " may prove effective for small fruit trees, but is not economical to use on large trees. Sticky bands prepared with a mixture of resin and castor oil also proved very effective.

Stored wheat at Pusa usually gets badly infested with weevils (*Sitophilus oryzae*) and sometimes the damage caused by this insect results in a loss of about twenty per cent. of the stored quantity. Very encouraging results were obtained by the use of mercury in stored wheat, which remained in excellent condition from May to the following January when it was converted into flour. To ascertain the action of mercury vapour on insect life, eggs of bugs, beetles, moths, butterflies, etc., were placed in stoppered phials, one series having a little mercury in a tube fixed in the centre of the phial and the other series without mercury, to act as " controls." Eggs in the mercury phials did not hatch at all, while those in control phials hatched without any exception. The experiment was repeated and yielded the same result. Further experiments were started to watch the physiological effect of mercury vapour on stored wheat, but the results are not conclusive yet.

The terminal leaves on the shoots of *Hibiscus cannabinus* plants in an experimental plot of the Imperial Economic Botanist, curled up into compact knots. Two different kinds of insects were present in numbers on the shoots, one a Capsid bug and the other *Pseudococcus* sp. To know definitely which of the two insects was responsible for the damage, six healthy and clean shoots of plants were selected and sleeved. Inside three sleeves Capsid bugs were liberated and in the remaining

three *Pseudococcus* sp. Shoots with *Pseudococcus* sp. produced the characteristic curly leaves.

In July 1926, the Imperial Economic Botanist reported that plum trees in the Botanical Area were severely damaged by an insect. Almost all the leaves of the trees were entirely riddled. Cockchafer beetles were found to be responsible for the damage. Spraying the affected trees with lead arsenate proved very successful.

Diacrisia obliqua appeared in a very serious form during August and September 1926, both in the Botanical Area and on the Farm. A report from the Imperial Economic Botanist was received when the caterpillars had reached an advanced stage of development and had scattered all over the area. Still, whatever was possible was done to check them, but it gave us warning to be ready for the next brood. As soon as moths were noticed light-traps were set up to attract them in numbers, the egg-masses were collected as far as possible, but a special effort was made to handpick the caterpillars while they were still in clusters. Thus a very large number of caterpillars was accounted for. Counts were also kept in a few cases and it was found that one boy, on an average, could collect 44 clusters of caterpillars in an hour. The average number of caterpillars in one cluster was roughly 886 ; thus about 39,000 caterpillars were destroyed by one boy in one hour.

A species of *Phenacoccus*, presumably *insolitus*, was found at Pusa attacking brinjal (*Solanum melongena*) leaves for the first time. The attacked leaves were almost withered. *Ph. insolitus* has so far been recorded on this food-plant from Chinglepet, Saidapet, and Coimbatore, *i.e.*, from Southern India only.

Diacrisia obliqua was found on beet-root. It is a new food-plant for this insect, which usually attacks all low-growing vegetation. The caterpillars feeding on red-beet were noted to be of an unusually red colour.

Agrotis ypsilon was noticed for the first time cutting shoots of growing carrots.

Wheat (Pusa 12) in the Punjab Experimental Area was slightly attacked by Aphids which were in turn parasitized by a species of *Aphidius* (?). The percentage of parasitization was low, only four per cent. in February but later rose to seventeen per cent. in March.

In December 1926 numbers of *Myllocerus maculosus* (Curculionidæ) were collected to breed out a Braconid parasite (? *Loxocephalus* sp.) which attacks the adult weevil. The beetles were collected from the fields and liberated in a cage provided with fresh tender *tur* (*Cajanus indicus*) shoots. A few parasites were thus bred out from the weevils. It was observed that the weevils died soon after the emergence of the parasitic larva from the body, but so long as the parasitic larva remained inside, the weevil did not show any signs of sluggishness or discom-

fort. It has not been possible so far to detect any external difference between the parasitized or non-parasitized weevils. Another point of interest which was observed in the behaviour of the parasite was that the female doggedly pursued the adult weevil from branch to branch and from leaf to leaf till she found a favourable opportunity to " sting " the weevil, which she did by doubling the abdomen below her body so that the ovipositor which protruded beyond her head was thrust into the hind end of the weevil on the ventral surface. (Plate X.)

A serious outbreak of *Spodoptera mauritia* on paddy in the Champaran District in September 1926 was dealt with.

Prodenia litura and *Hellula undalis* proved serious pests of cauliflower seedlings at Pusa in September 1926 and were checked by spraying with lead arsenate.

Jamides bochus was reported in November 1926 as damaging oranges in the Ranchi District. This has not been known as a pest of Citrus previously, but has been recorded as feeding on *Xylia dolabriformis* and on flowers of *Butea frondosa*.

Pyralid larvæ, sent in as damaging Cinchona at the Government Cinchona Plantation, Kalimpong, were reared out and identified as *Margaronia marinata*, Fb.

Dynastine beetles damaging sugarcane at Myitkyina, Burma, were received in May 1927 and necessary information was given.

A small flight of Locusts (*Schistocerca gregaria*, Forsk.) passed eastwards just North of the Pusa Estate on 28th June 1927. Fieldmen were sent out, but the locusts had flown on without doing damage. In other parts of India, however, locusts have occurred in some numbers this year and information of their occurrence has been received from the United Provinces and the North-West Frontier Province, an Assistant being sent to Peshawar in May to give assistance there.

Large numbers of *Chaetodacus cucurbitæ* have been bred out with a view to obtaining parasites, but hitherto with entirely negative results. It is known that this Fruit-Fly is parasitized in other parts of India, notably at Bangalore, where were obtained specimens of *Opius fletcheri* which has been introduced into Hawaii with very beneficial results.

Pathological Entomology.

Work on the life-histories and distribution of Tabanidæ was continued by Mr. P. V. Isaac.

A series of experiments was carried out to ascertain why the mosquitos, *Aedes* (*Stegomyia*) *albopictus*, Skuse, and *Culex fatigans*, Wied., oviposit in certain places and not in others apparently equally favourable. It was found that infusions of hay of wheat, rice, oats, pulses and potatoes, diluted and allowed to rot, were very attractive to those mosquitos. Stagnant and distilled water were used as standard control

which were renewed weekly. The addition of a poison to those infusions, in some cases, exercised no inhibitory effect, the poisoned infusions proving just as attractive as the plain infusions and more so than the controls, although the chemicals used showed marked effects on the larvæ that hatched out, often resulting in early death.

A single specimen of *Harpagomyia genurostris*, Leic., was found at Pusa on 2nd December 1926, this being the first local record for this scarce mosquito.

Further specimens of Muscid maggots, and of the resulting flies, attacking elephants in Burma, were received from the Veterinary Adviser to the Government of Burma and have been sent to Major E. E. Austen, D.S.O., for description.

Larvæ of the Dytiscid beetle, *Hyphoporus ater*, Sharp, were noted to attack both Culicine and Anopheline mosquito larvæ, but not egg-masses or pupæ, in the river at Pusa.

A campaign to reduce the mosquito nuisance in the Pusa Estate was carried out, the breeding places being traced down, mapped and dealt with. A very considerable reduction in the numbers of mosquitos in the Estate was effected.

Life-history work.

The usual work was continued in the Insectary, the life-histories of the insects under rearing being followed up by the Artists and the stages drawn.

IV. Bees and Lac.

Apiculture. Numerous requests for advice and apparatus have been received during the year and complied with as far as possible. There is a constant small demand for hives, foundation-comb, and such apparatus as smokers and excluder-sheets. The hives can be prepared under our instruction by a local carpenter and the comb can be turned out in our foundation-machine, which is designed for *Apis indica*, but there seems to be no source of supply in India for the other apparatus required for this industry.

Lac. The emergence of lac larvæ took place on the following dates :—

(1) At Pusa. *Palas* lac on *Palas* on 1st July 1926.
(2) At Daltonganj. *Palas* lac on *Ber* on 5th July 1926.
(3) At Pusa. Old *Ber* lac on *Ber* on 5th July 1926.
(4) At Chaibassa. *Ber* lac on *Ber* on 15th July 1926.

On account of deterioration, there was no emergence of lac at Pusa in October 1926.

A consignment of *Kusum* lac was received from the Forest Office, Palamau, in February 1927, and is doing well on *Kusum*.

Seeds of lac-bearing trees have been obtained and planted and a consignment of vigorous young *Ber* trees has also been obtained and planted, with a view to the renewal of lac-culture at Pusa.

V. Insect Survey.

Collections were sent out for identification by the following specialists, whose kind help is gratefully acknowledged :—

(1) Coprid Beetles—Mr. G. J. Arrow, British Museum.
(2) Jassoidea—Zoological Survey, Calcutta.
(3) Embiadina—Zoological Survey, Calcutta.
(4) Gryllidæ—Imperial Bureau of Entomology.
(5) Braconid Parasites of cane borers—Imperial Bureau of Entomology.
(6) Bruchidæ—Government Entomologist, Madras, for Mr. Bridwell.
(7) Gryllacridæ—Mr. Uvarov.
(8) Meloid and Malacodermid Beetles—Mr. K. G. Blair.
(9) A Muscid Fly parasitic on elephants in Burma—Major E. E. Austen, D.S.O.
(10) Tridactylidæ and (11) Acrididæ—Mr. Uvarov.
(12) Hydrophilidæ—M. d'Orchymont.
(13) Bombylidæ and other Diptera—British Museum.
(14) Culicidæ—Captain Barraud, Kasauli.
(15) Dytiscidæ—Dr. Zimmermann, Germany.
(16) Scoliadæ—Professor Rœpke for Mr. Betrem.
(17) An Aphidid—Imperial Bureau of Entomology.
(18) Hippoboscidæ—Major E. E. Austen, D.S.O.
(19) Fleas—Mr. Sharif, Zoological Survey, Calcutta.

The collections remain in tolerably good order, but the difficulties due to changes of Assistants have already been referred to. The majority of the collections, also, are still contained in old Store-boxes, which require constant attention.

Numerous insects were received from correspondents and names and information given as far as possible.

Requests from other entomologists for Indian insects were complied with as far as possible and the following specimens were sent :—

(1) *Aleyrodidæ*, to the Entomologist, Newark, Delaware, U.S.A.
(2) *Culicoides*, to the Kala-Azar Commission.
(3) *Thosea unifascia*, to the British Museum.
(4) *Fruit-flies*, to Mr. J. Khare, Nagpur.
(5) Insects representative of the larger Orders, to the Zoology Department, Allahabad University.

(6) Living examples of Lepismatids, to A. G. Farbenindustries, Germany, for experimental purposes.
(7) Diptera, to Dr. R. Frey, Finland (in exchange).
(8) Lepidoptera and Coleoptera, to Herr O. Spicak, Czekoslovakia.
(9) Sphingidæ, to Mr. Preston Clark, U.S.A.
(10) Examples of Plecoptera, Panorpidæ, and Trichoptera, to the Government Entomologist, Punjab.
(11) Living examples of Paussid beetles, to Mr. Ribeiro, Zoological Survey, Calcutta.

VI. Catalogue of Indian Insects.

Comparatively slow progress can be reported. Only one part (Part 11—Brenthidæ, by R. Kleine) has actually been published during the year, but other parts, on Cicindelidæ, Tabanidæ, and Cecidomyiadæ, were in the press at the close of the year, and it is hoped to issue yet others in the following year.

VII. Programme of work for 1927-28.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and specially of the pests of sugarcane, rice and cotton, of fruit trees, and stored grain, and also work on insect pests of domestic animals.

Minor.

Results in various lines require to be written up and published as far as possible. New insecticides and insecticidal methods will be tested as occasion arises. Systematic work will be carried out with our resources, and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

VIII. Publications.

The following publications, either prepared by the Pusa staff or founded in whole or in part on material sent from Pusa, have actually been issued during the year ended 30th June 1927 :—

Fletcher, T. Bainbrigge; and Husain, M. Afzal. — List of Publications on Agricultural Entomology 1925 (*Pusa Bulletin* No. 165).

FLETCHER, T. BAINBRIGGE; AND SEN, S. K. — A Veterinary Entomology for India (*Jl Centr. Bur. Anim. Husb. Dairying India*, I, 9-15; June 1927).

MAULIK, S. — Chrysomelidae (Chrysomelinæ and Halticinæ), *Fauna of British India;* pp. xiv, 442, 139 figs. London, Apl. 1926 [Omitted from last year's Report.]

MEYRICK, E. — Exotic Microlepidoptera, Vol. III, Parts 10 (November 1926) and 11 (January 1927).

,, — Description of *Laspeyresia stirpicola*, n. sp. (*Ind. Agr. Ent. Mem.*, IX, 259; Sept. 1926).

MISRA, C. S. — A short note on the life-history and status of *Laspeyresia stirpicola*, Meyr. (*Ind. Agr. Ent. Mem.*, IX, No. 9: Sept. 1926).

PROUT, L. B. — New Indian Geometridæ. (*Ind. Agr. Ent. Mem.*, IX, No. 8; Sept. 1926).

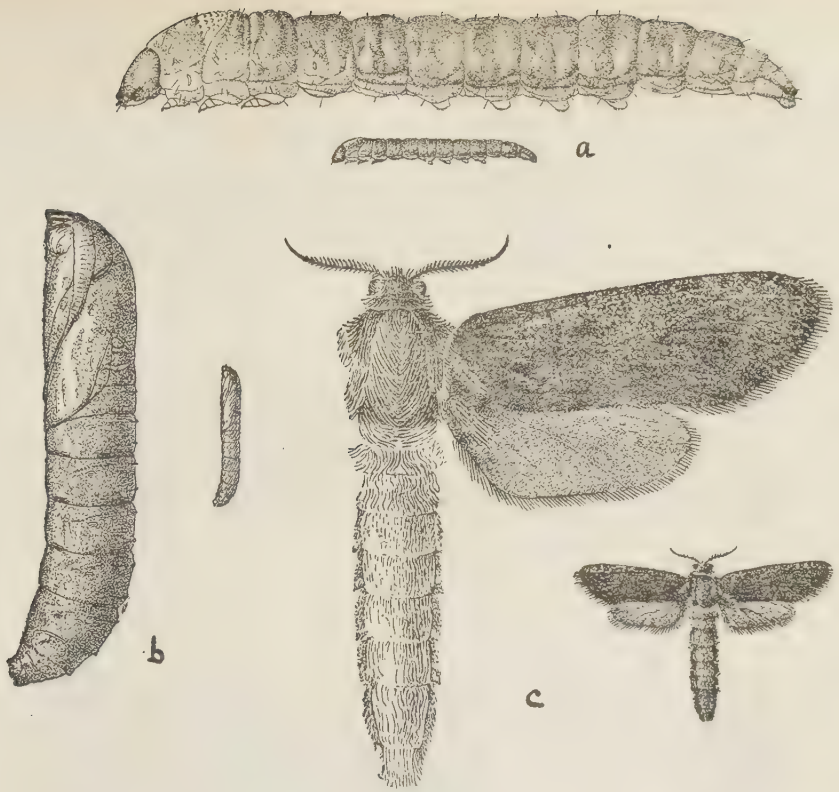
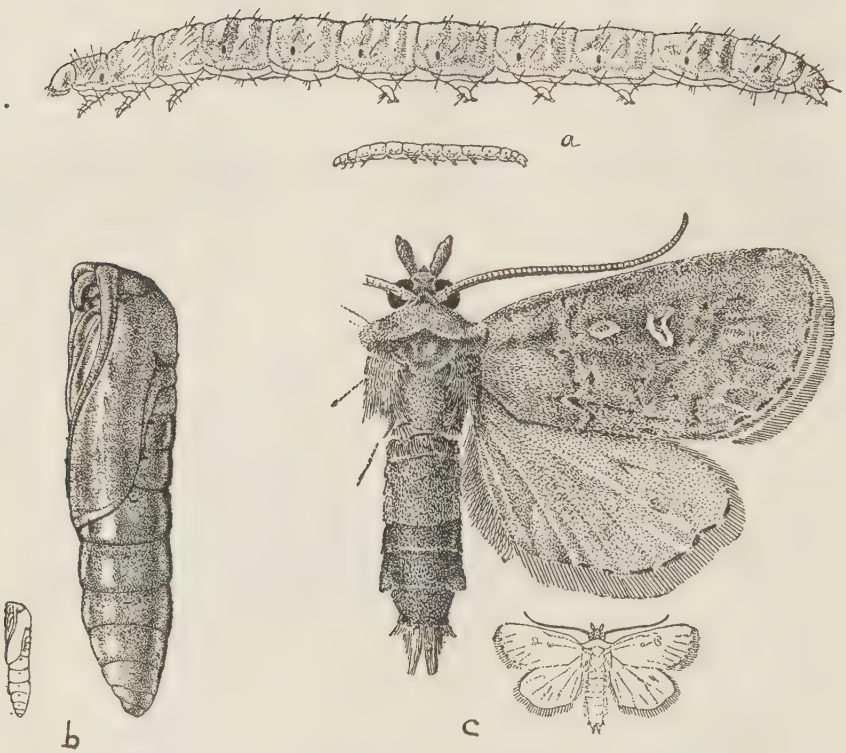


Fig. 1. *Phragmatoecia purpureus*, n. sp. ; *a*, larva ; *b*, pupa ; *c*, moth ; all magnified ; the small figures show the natural sizes.

PLATE II.



Busseola sacchariphaga, n. sp.; *a*, larva (×4); *b*, pupa (×4); *c*, moth (×4); the smaller figures show the natural sizes.

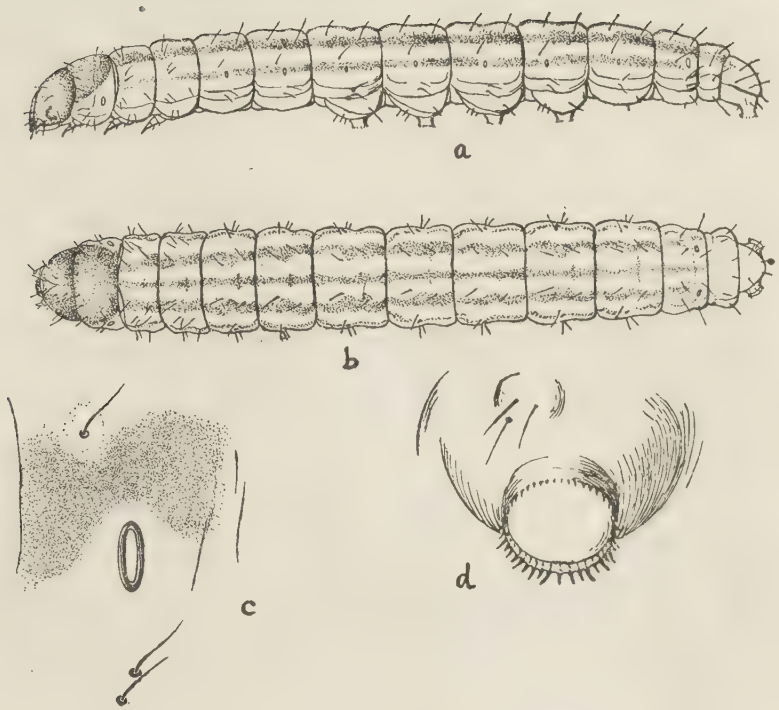


Fig. 1. *Chilo oryzae*, n. sp. ; *a*, larva, side-view ×5 ; *b*, larva, dorsal view ×5 ; *c*, details of spiracle ; *d*, arrangement of crochets on proleg of larva.

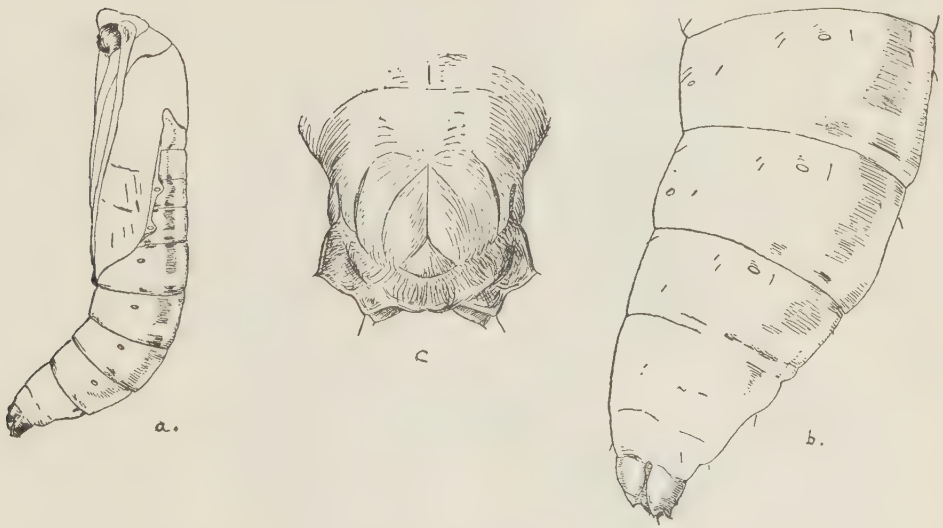


Fig. 2. *Chilo oryzae*, n. sp. ; *a*, pupa ×5 ; *b*, posterior segments of pupa, seen laterally, more highly magnified ; *c*, anal segment of pupa, ventral surface, more highly magnified.

PLATE IV.

Chilo oryzae, n. sp. Moths ×5. The smaller figures indicate the natural sizes.

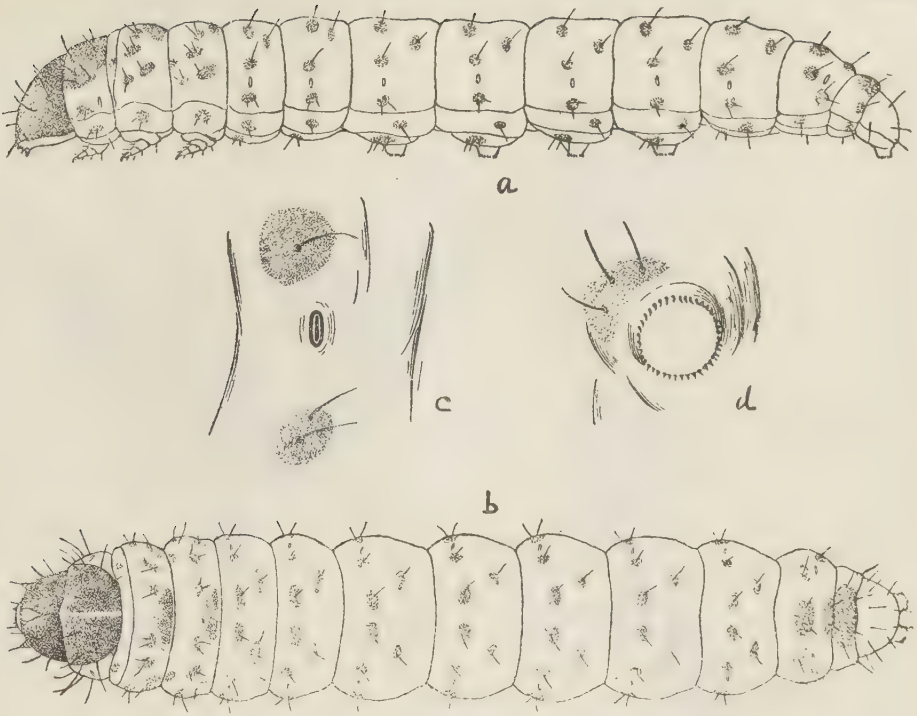


Fig. 1. *Diatraea kanra*, n. sp. *a*, larva, lateral view ×5; *b*, larva, dorsal view ×5; *c*, details of spiracle; *d*, arrangement of crochets on proleg.

Fig. 2. *Diatraea kanra*, n. sp. Moth, natural size and magnified.

PLATE VI.

Fig. 1. *Dratraea kanra*, n. sp. *a*, pupa, posterior portion from side (× 13); *b*, anal segment of pupa, end view more highly magnified.

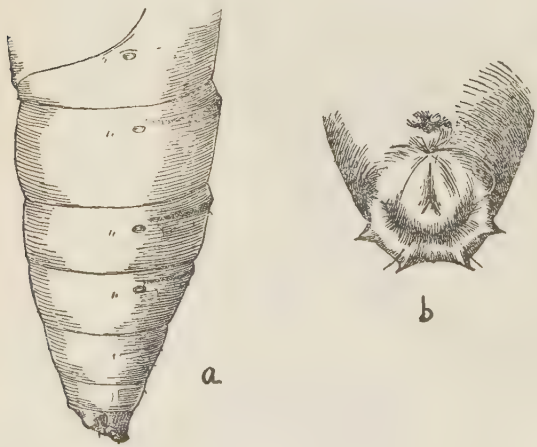


Fig. 2. *Chilo saccharicola* n. sp. *a*, posterior portion of pupa, magnified; *b*, anal segment of pupa posterior view, magnified.

Fig. 3. *Chilo saccharicola*, n. sp. Moth, natural size and magnified.

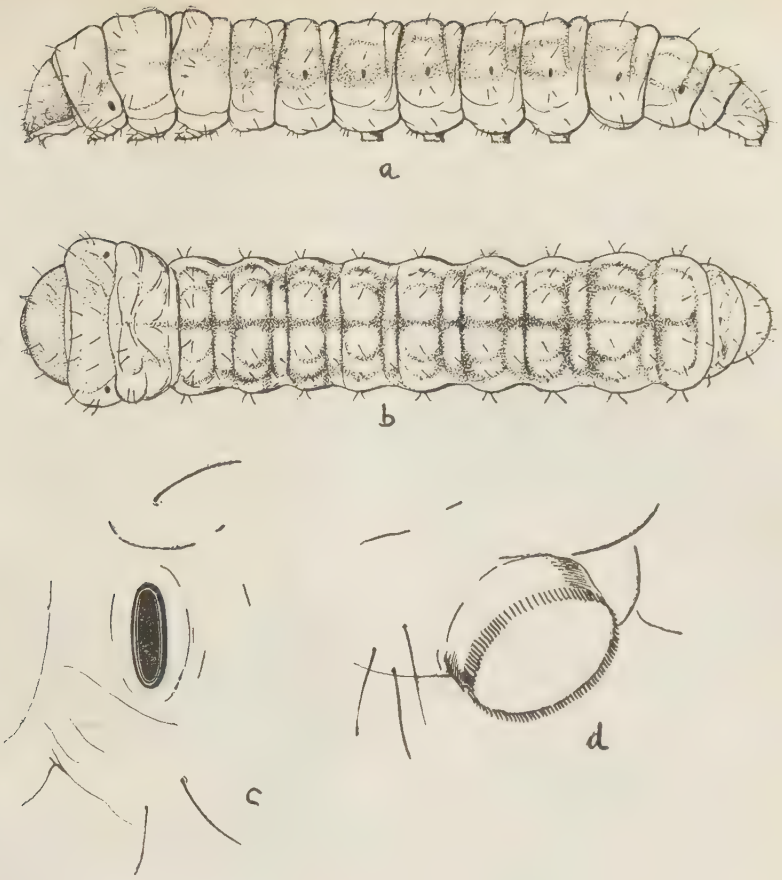


Fig. 1. *Diatraea batri*, n. sp. *a*, larva, side-view ×5; *b*, dorsal view ×5; *c*, details of spiracle; *d*, arrangement of crochets on proleg.

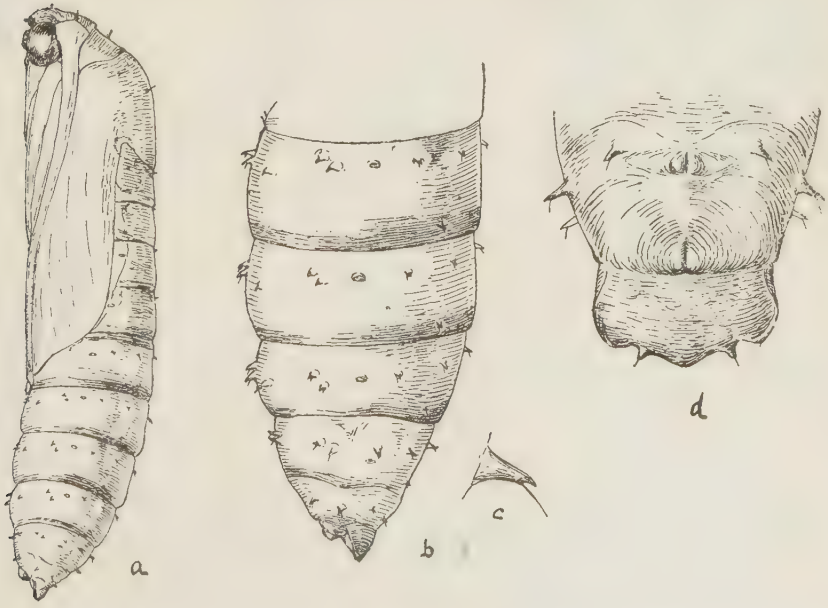


Fig. 2. *Diatraea ikri*, n. sp. *a*, side-view, magnified ×5; *b*, posterior extremity, side-view, more highly magnified; *c*, a single spine, more highly magnified; *d*, anal segment, highly magnified.

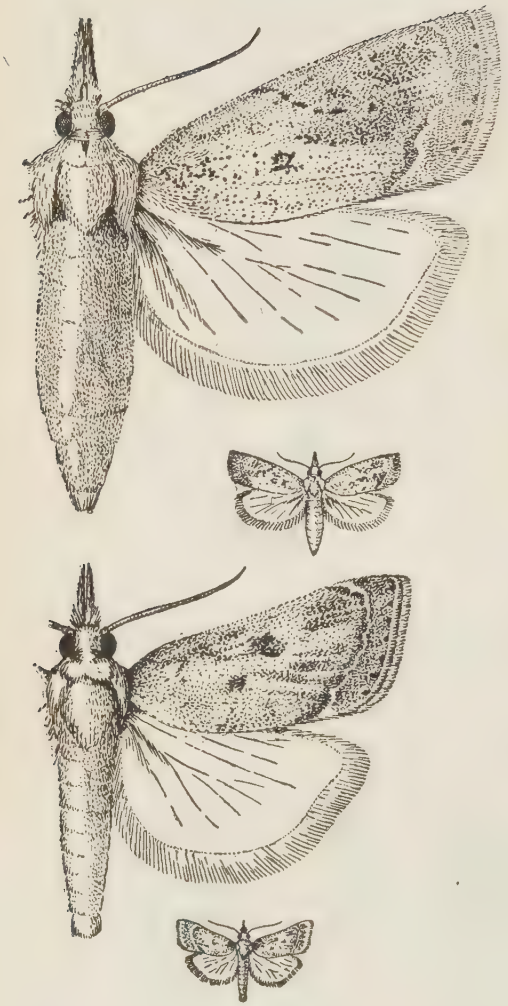


Fig. 1. *Diatraea batri*, n. sp. Moths × 5. The smaller figures indicate the natural sizes.

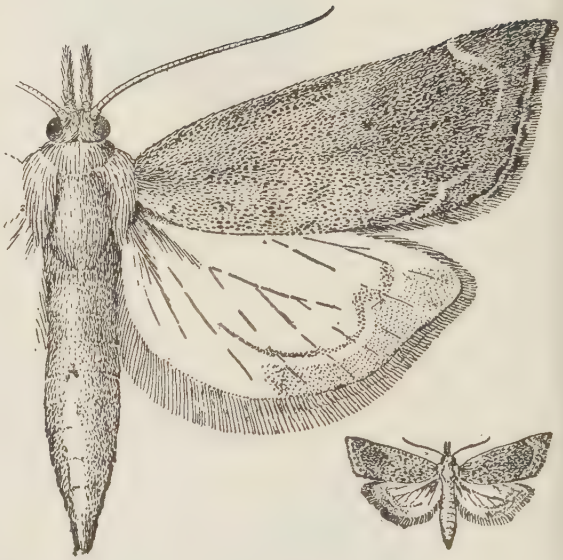


Fig. 2. *Diatraea ikri*, n. sp. Moth, natural size and magnified (×5).

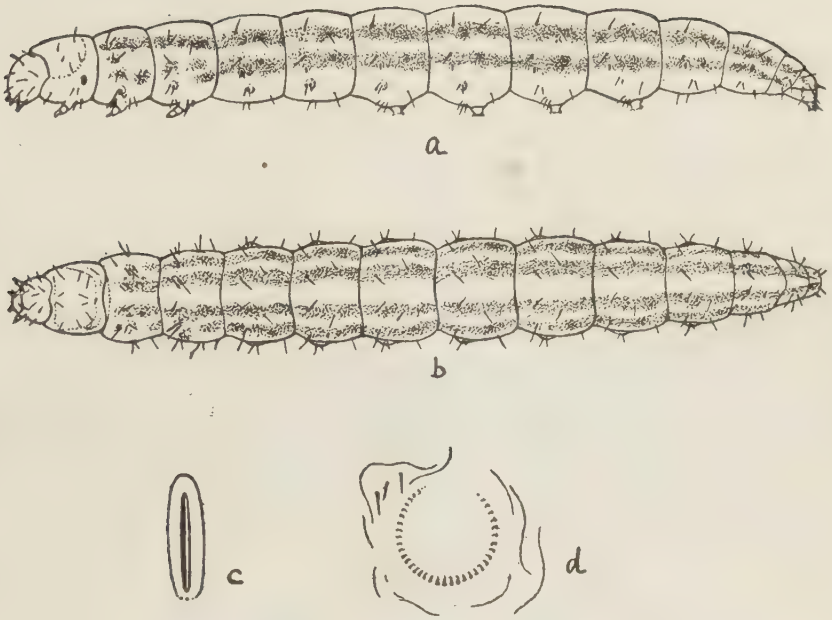


Fig. 1. *Diatraea ikri*, n. sp. *a*, larva, side-view × 5 ; *b*, larva, dorsal view × 5 ; *c*, spiracle more highly magnified ; *d*, arrangement of crochets on proleg of larva.

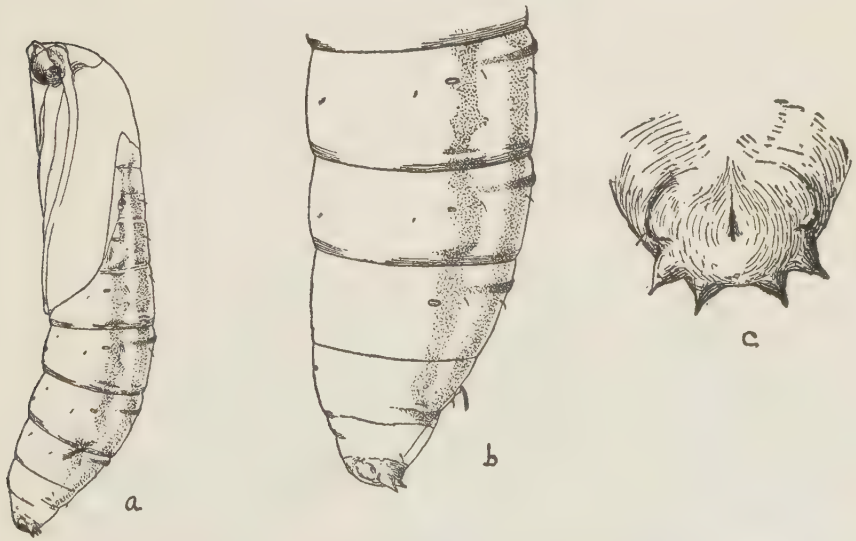
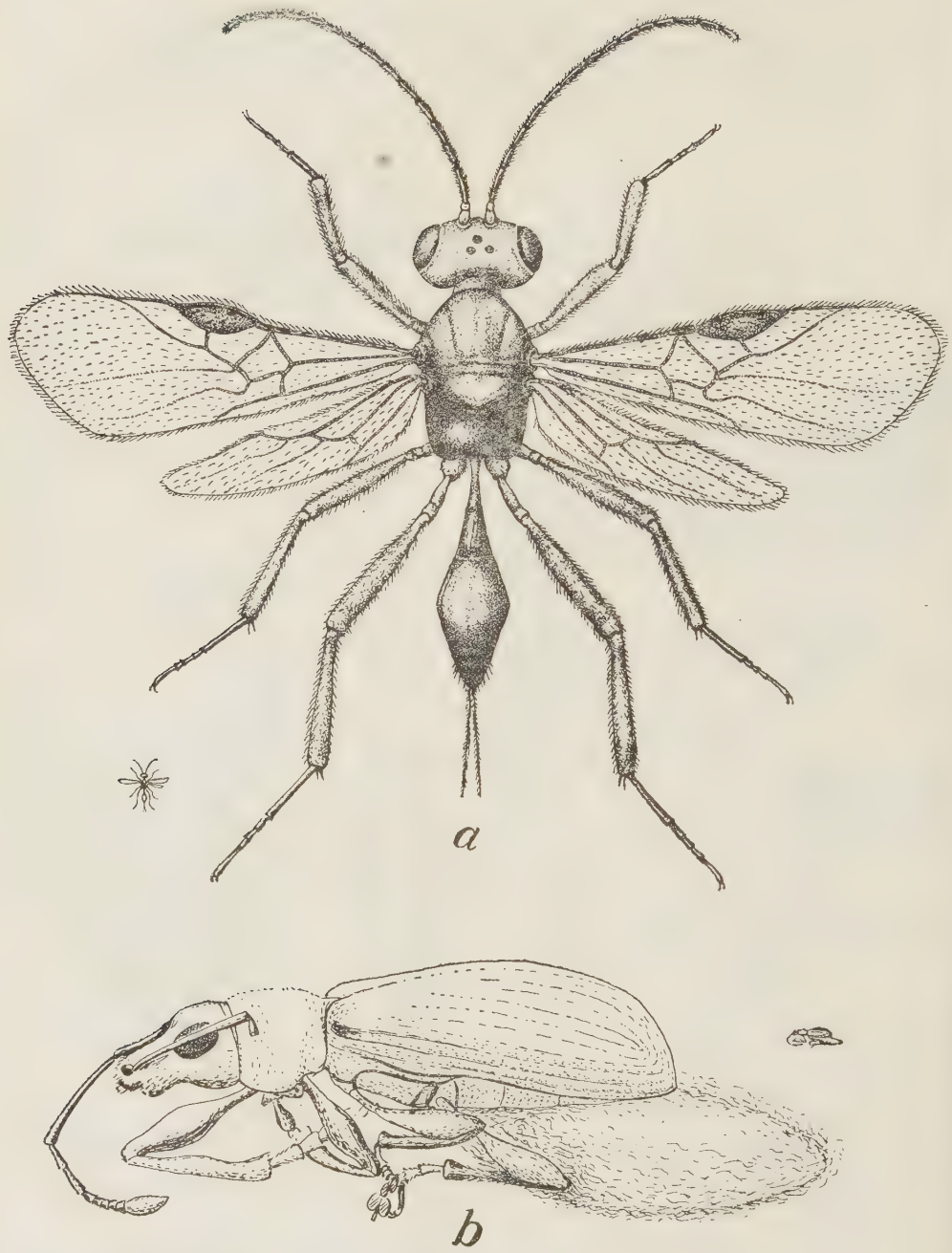


Fig. 2. *Diatraea batri*, n. sp. *a*, Pupa × 5 ; *b*, posterior extremity of pupa, side-view, more highly magnified ; *c*, posterior extremity of pupa, anal view, more highly magnified.

PLATE X.



A Braconid parasite of adult *Myllocerus maculosus* ; *a*, the parasite (? *Loxocephalus* sp.) × 18 ; *b*, the parasitized weevil, with the parasitic cocoon *in situ* × 12.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Charge.

Mr. G. S. Henderson, N.D.A., N.D.D., resumed charge of the office of Imperial Agriculturist on 22nd October, 1926, on return from leave, and held charge of the Agricultural Section for the rest of the year.

Mr. Arjun Singh Maan, L.Ag., Assistant to the Imperial Agriculturist, remained in charge of the current duties of the Imperial Agriculturist, in addition to his own, during the absence of Mr. Henderson on leave.

Mr. L. S. Joseph, Cattle Superintendent, was in charge of the cattle-breeding operations throughout the year, while Mr. Jamaluddin, Second Cattle Superintendent, remained in charge of the dairy.

Mr. Aga Md. Mustafa, B.A. (Oxon.), was attached to this Section as Agronomist during the year under report. He was engaged on preliminary work and in the collection of statistics.

II. Touring, advising and seed distribution.

The Imperial Agriculturist judged cattle classes at Poona Show in October and toured in Bihar in December 1926 and in February 1927 to see various centres of sugarcane grown from Coimbatore seed raised at Pusa. He was made a Member of the Advisory Board of the Lac Institute at Ranchi and inspected this new Institute in March 1927 giving general information to the Lac Committee. In March and April 1927, he visited the Punjab and attended the meeting of the Advisory Committee of the Punjab Government on salt land reclamation work on the Bara Farm, the land of which was hard, impenetrable alkaline soil. This work is progressing favourably. In April a visit was paid to the Bettiah Raj and a scheme was drawn up for a home farm and cattle-breeding operations. In June the cattle farms at Bangalore, Wellington and Karnal were visited in conjunction with the Imperial Dairy Expert. General advice on agriculture was given and the livestock was valued for audit purposes.

While in England on leave, the Imperial Agriculturist attended the Congress of the International Institute of Agriculture at Rome as one of the two Indian delegates, and tried to impress on the Congress the necessity for more work in tropical agriculture.

Seventy-five growers were supplied with miscellaneous samples of improved seed, etc., produced on the Pusa farm. The major quantities distributed consisted of 470 md. of seed oats and 1,800 md. of improved sugarcane sets.

III. Training.

One post-graduate student received training in general agriculture and cattle-breeding from 5th February to 30th April, 1927, and completed his course of training in dairying and animal husbandry.

Three Kamdars were trained and supplied to the Bihar and Orissa Government for local propaganda work.

IV. Pusa farm and cultivation.

Season. The total rainfall from June 1926 to May 1927 amounted to 38·74 inches as compared with 48·67 inches for the corresponding period of the previous year. There was no appreciable amount of rain during the whole of June and the first half of July for *kharif* sowing. Sowing started in July, germination was unsatisfactory and crops were beaten down by the fall of 7·30 inches of rain on 16th July, and heavy rain during the latter half of the month made further *kharif* sowing too late. The *kharif* crop on the non-irrigated farm area was therefore very poor.

Moisture was deficient for *rabi* sowing as there was no rain in the month of October 1926. The *rabi* crops got only half an inch of rain in January 1927 and a similar amount in February. Consequently, the the straw of cold weather cereals was short.

Generally, the distribution of the monsoon rainfall was very unsatisfactory. The major portion fell in the last half of July and August.

V. Field experiment work.

(*a*) The following are the results of the permanent manurial and rotational experiments for 1926-27. This series of experiments has been carried out for a number of years and the results are very consistent.

The seeds from some of the plots from the permanent manurial experiments were supplied to the Officer-in-Charge, Deficiency Diseases Enquiry in Coonoor, for study in connection with his research.

Table I.

Results of permanent manurial and rotation experiments for 1926-27.

Plot No.	Treatment	A Series			B Series		
		Maize grain per acre in lb.	Arhar grain per acre in lb.	Barley grain per acre in lb.	Maize grain per acre in lb.	Oats grain per acre in lb.	Peas grain per acre in lb.
1	No manure	427	747	..	349	320	..
2	Farmyard manure to supply 10 lb. nitrogen per acre.	558	673	..	608	443	..
3	Farmyard manure to supply 20 lb. nitrogen per acre.	727	829	..	739	542	..

Plot No.	Treatment	A SERIES			B SERIES		
		Maize grain per acre in lb.	Arhar grain per acre in lb.	Barley grain per acre in lb.	Maize grain per acre in lb.	Oats grain per acre in lb .	Peas grain per acre in lb.
4	Farmyard manure to supply 30 lb. nitrogen per acre.	899	780	..	764	649	..
5	Rape-cake to supply 20 lb. nitrogen per acre.	755	796	..	608	394	..
6	Sulphate of ammonia to supply 20 lb. nitrogen per acre.	337	854	..	583	337	..
7	Sulphate of potash to supply K_2O as in farmyard manure plot No. 3.	345	732	..	411	287	..
8	Superphosphate to supply P_2O_5 as in farmyard manure plot No. 3.	714	723	..	673	468	..
9	Sulphate of potash to supply K_2O and superphosphate to supply P_2O_5 as in farmyard manure plot No. 3.	567	632	..	526	509	..
10	Sulphate of ammonia to supply nitrogen, sulphate of potash to supply K_2O and superphosphate to supply P_2O_5 as in farmyard manure plot No. 3.	657	640	..	854	501	..
11	No manure or leguminous crop .	265	..	382	353	394	..
12	Green manure in a cereal rotation .	509	..	357	Green manure	476	..
13	Deep-rooted leguminous crop in a cereal rotation.	213	764	..	411	213	..
14	One deep-rooted and one shallow-rooted legume in the rotation.	267	846	..	444	181	16
15	Green manure and leguminous crop in the rotation.	583	682	..	Green manure	443	..
16	Green manure and superphosphate to supply P_2O_5 as in farmyard manure plot No. 3	1,043	567	..	Green manure	1,363	..

(*b*) *Wilt manurial plots.* These plots did not give such uniform figures with maize and *arhar* (*Cajanus indicus*) as they did in the previous year with oats. In previous years, all the wilt plots with green manure and superphosphate gave 2,000 lb. oats per acre. It will be interesting to see if similar results will be obtained in the following year when the oats rotation comes again.

TABLE II.

Plot No.	Treatment per acre	A SERIES		B SERIES	
		Maize grain per acre in lb.	Arhar grain per acre in lb.	Maize grain per acre in lb.	Arhar grain per acre in lb.
1	Check—P_2O_5 60 lb.	626	72	1,098	103
2	P_2O_5 20 lb.	955	62	1,222	267
3	Check—P_2O_5 60 lb.	503	174	513	370
4	$MgSO_4$ $7H_2O$ 150 lb. ; P_2O_5 60 lb. . .	523	144	544	123
5	Check—P_2O_5 60 lb. . . .	400	164	411	103
6	$MgSO_4$ $7H_2O$ 300 lb. ; P_2O_5 60 lb. . .	359	103	390	103
7	Check—P_2O_5 60 lb. (bonemeal) . .	390	185	616	257
8	$Fe_2(SO_4)_3$ 150 lb. ; P_2O_5 60 lb. . . .	472	144	575	246
9	Check—P_2O_5 60 lb.	328	216	349	185
10	$Fe_2(SO_4)_3$ 150 lb. ; P_2O_5 60 lb. . . .	657	216	616	174
11	Check—P_2O_5 60 lb.	370	133	298	164
12	$Fe_2(SO_4)_3$ 150 lb. ; P_2O_5 60 lb. . . .	636	298	493	205
13	Check—P_2O_5 60 lb.	226	370	267	287

(*c*) *Green-manuring experiments* with superphosphate for the Imperial Agricultural Chemist gave the following very significant results :—

TABLE III.

Plot No.	Treatment	Oats per acre in lb.
1	No manure	416
2	Green manure alone	785
3	Superphosphate—50 lb. P_2O_5 per acre	523
4	Green-manure and superphosphate—50 lb. P_2O_5 per acre	924
5	No manure	462
6	No manure	431

(*d*) In the series of trials for suitable *kharif* and *rabi* pulses, the outturn were as follows :—

TABLE IV.

Outturn of seed in lb. per acre during 1926-27.

Serial No.	Name of pulses	Highest outturn in lb. per acre	Average outturn in lb. er acre
	Kharif PULSES.		
1	Soybean (*Glycine hispida*)	1,068	1,051
2	Cowpeas (*Vigna Catjang*)	599	546
3	*Meth* (*Phaseolus aconitifolius*)	1,622	1,476
4	*Guar* (*Cyamopsis psoralioides*)	1,421	1,273
5	Velvet bean	411	406
	Rabi PULSES.		
6	Peas, white flower	550	538
7	Peas, purple flower	928	899
8	*Val* (*Dolichos lablab*)	435	423 (Green stuff 6,815 lb. per acre)
9	Gram P. F. 3	1,380	1,314
10	Gram P. F. 5	1,240	940
11	Gram P. F. 15	435	435
12	Gram P. F. 16	762	734
13	Gram P. F. 17	1,035	948
14	Gram Pusa 17	1,141	1,141

(*e*) *Miscellaneous.* Trials with wheat were made for the Imperial Economic Botanist and experiments were made with *arhar* wilt for the Imperial Mycologist. Experiments were carried out for the Fibre Expert in extracting fibre from sann-hemp at different stages of growth. The agricultural seed selection of the staple farm crops was continued in the Punjab field. The best results have been obtained with strains of maize, oats and *arhar*. Progress has also been made with the chilli collection, one of which No. 8 gave 40 maunds per acre.

The fodder grasses under trial are Rhodes, Natal, Para, Vassi and Kikuyu ; these had no growth in the cold weather and only grew well during the monsoon.

Experiments with artificial manures, chiefly with sugarcane, were carried out.

(*f*) *Fertility experiment.* 413 acres outside the field experiment area were cropped under a three-year rotation designed to supply grain and fodder for the upkeep of the pedigree dairy herd. Yields for the past fifteen years are given below. There is a drop in the present season, but this is only a seasonal fluctuation. The fertility shows a steady upward tendency for the last fifteen years. This is due to the intimate relation between agriculture and cattle rearing. About 80 head of cattle are kept per 100 acres of arable ground.

TABLE V.

Yield of 13 fields (413 acres) for the last 15 years.

Year	Annual rainfall	Oats and other cereals	Maize	Pulses	Total grain	Green stuff for fodder and silage
	Inches	Md.	Md.	Md.	Md.	Md.
1912-13 . .	41·26	2,210	522	894	3,626	16,301
1913-14 . .	61·74	1,997	200	1,100	3,297	11,513
1914-15 . .	54·88	1,749	534	704	2,987	14,427
1915-16 . .	51·37	2,669	884	701	4,254	36,903
1916-17 . .	59·67	2,897	670	932	4,499	31,971
1917-18 . .	45·54	2,376	1,276	1,010	4,662	30,893
1918-19 . .	60·19	3,386	559	1,037	4,982	30,735
1919-20 . .	32·73	2,479	1,064	719	4,262	31,624
1920-21 . .	44·33	2,542	766	1,073	4,381	33,359
1921-22 . .	39·82	3,754	1,267	1,132	6,153	34,492
1922-23 .	65·78	3,752	496	941	5,189	23,021
1923-24 . .	24·88	2,448	988	1,100	4,536	29,146
1924-25 . .	57·00	5,816	467	1,234	7,517	20,936
1925-26 . .	48·67	4,611	343	1,030	5,984	22,906
1926-27 . .	38·74	4,131	540	512	5,183	21,293

VI. Crops.

Oats. The best yield per acre was 22 md., but the flooded Brickfield only gave 10 md. The average outturn in 265 acres was $15\frac{1}{2}$ md.

Maize and leguminous fodder crops. These all over were satisfactory and plenty of fodder was available all the year round for cattle. Also fodder crops were available for grazing by the cattle all the year round. Fifteen thousand maunds of maize silage was made in pits as usual. The regular cycle for cattle grazing is as follows :—

Cold weather—Berseem.
Hot weather—Maize and *meth* irrigated.
Rains—Maize, *guar* and *meth* unirrigated.
Late sown *meth* and soybean are available to carry on the grazing till the berseem is ready in November.

Sugarcane. The temporary arrangement by which an area of 160 acres was given on lease to the Indian Sugar Producers' Association for work with the new varieties of Coimbatore sugarcanes was terminated. This New Area was resumed by the Agricultural Section. The standing crop was taken over from the Secretary, Sugar Bureau, of some 30 acres cane, and 10 acres were also cultivated on the main farm. The Secretary, Sugar Bureau, was in continuous touch with the work.

New Area land. Since this land has been resumed, systematic development has begun. Cane will occupy annually a block of some 30 acres. A permanent nursery for the preliminary small scale trial of Coimbatore varieties has been laid out. The necessary buildings have been erected. These buildings demonstrate a new system of cheap portable units suitable for all classes of farm buildings. One 30-acre block of land has been levelled ready for irrigation, and the whole area is now commanded by irrigation from the river Boor Gandak by a portable steam engine and an 8″ centrifugal pump.

The canes are not proposed to be irrigated as irrigation is not general in Bihar, but irrigation will be available for protection in exceptional seasons and for growing leguminous fodder crops. The question of upkeep of fertility which is a very vital one in North Bihar, especially owing to the extension of cane cultivation, will be carefully studied. It is proposed to keep a number of young pedigree bulls on the leguminous catch crops. These bulls at present are usually sold, owing to lack of room, before they reach a breeding age.

The whole New Area will be a separate unit and will be a demonstration of the management of a block of land under intensive cane cultivation. The data obtained should be most valuable.

The programme consists mainly of the following work :—

(1) Testing new hybrid cane varieties received from Coimbatore ;
(2) Manurial experiments ;

(3) Seasonal and cultural experiments ;

(4) Collection of data regarding mosaic and other fungoid diseases and insect pests.

(1) *Testing new hybrid cane varieties received from Coimbatore.* The following varieties were grown on a field scale as they had passed through the preliminary nursery tests :—

Variety	Acres
Co. 205	1·98
Co. 210	10·48
Co. 213	18·63
Co. 214	3·11
Co. 248	0·03
Co. 250	0·27
Co. 270	0·09
Co. 273	1·07
Co. 275	2·01
Co. 280	1·16
Co. 281	0·25
Co. 282	0·01
Co. 287	0·14
Co. 288	0·12
Co. 290	0·36
Assami Red	0·01

The highest yield was obtained on the Pusa farm with Co. 205 at 774 maunds per acre.

The following notes regarding some of the above new cane varieties were compiled by the Secretary, Sugar Bureau :—

" Co. 248 grows fairly well and is medium thick. It is a cane worth persevering with. In 1926 mosaic markings were noticed on some clumps. These were rogued out and healthy sets were planted again. Up to date of writing, no mosaic has been noticed this year in this seedling.

" Co. 270, which tillers well and also appears to be drought-resistant, has been grown this year on a half-acre plot to test its yield per acre. It grows well and has been free from mosaic for the last two years.

" Co. 273, which is a promising seedling, has been planted this year on a field scale (2·05 acres) to determine its yield per acre against Co. 213. There is some infection from mosaic in the year 1927, while in 1926 it was free. This cane may prove suitable to certain silt areas where Co. 213 does not do its best.

" Co. 275 is a medium thick cane with good uniform germination and a useful habit of filling the rows completely. It was planted in February 1926 on a field scale (0·99 acre) in two plots. In one, the yield was at the rate of 503 maunds per acre, whereas in the other plot, which was very sandy, the results were poor, only 303 maunds per acre

being harvested. In order to test the yield against Co. 213, this variety has again been planted in February 1927 on 2·02 acres in one block. The condition of the growing crop is fairly satisfactory. It is, however, liable to mosaic. This year's results have also confirmed previous year's observations that Co. 280 will not make a good tonnage cane owing to its lack of tillering. It will accordingly be rejected."

New seedlings received from Coimbatore in 1926—Nos. Co. 294 to 306 and B. H. 10(12)—have been planted in the permanent nursery of the New Area and they will be noted on when cultivated under field conditions.

In February 1927, two new varieties, Co. 307 and Co. 308, were rereceived from Coimbatore, and have been planted in the permanent nursery ; also four Java seedlings P. O. J. 2696, 2714, 2725 and 2727.

Thirteen new Coimbatore canes selected by the Imperial Economic Botanist from seedlings were planted in the New Area nursery in February 1927.

(2) *Manurial experiments.* Manurial experiments were carried out with concentrated superphosphate, sugarcane mixture and nitrate of soda in comparison with mustard cake at the New Area on October-planted cane as well as on February-planted crop. As the land was not very uniform, the results were not conclusive.

Another experiment was carried on in the Bhograsan field on the main farm land with nitrate of soda in comparison with calcium cyanamide. The results show that the use of nitrate of soda is very suitable.

In the present year a comprehensive manurial scheme has been laid out in collaboration with the Imperial Agricultural Bacteriologist. The full scheme is given below :—

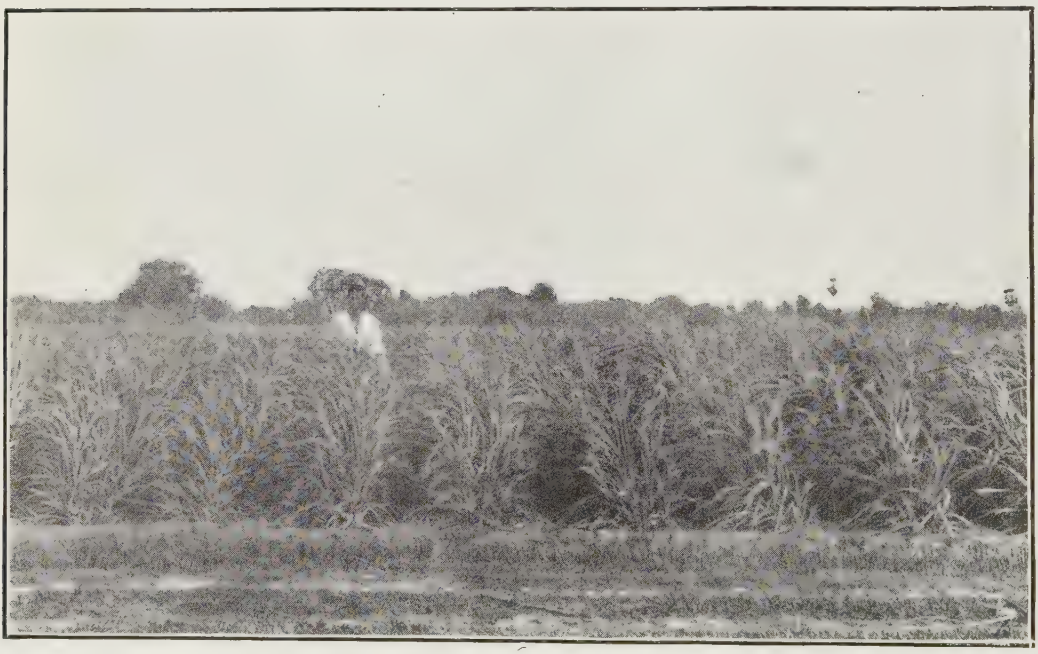
Scheme of plots for cane manuring experiments.

3	4 S	1	2	3	1	2
2 S	3 S	4 S	1 S	2 S	3 S	1 S
1	2	3	4 S	1	2	3

Plots numbered 1 receive 5 md. cake per acre.
„ „ 2 „ 10 „ „ „ „
„ „ 3 „ 15 „ „ „
1 2 3 2 „ superphosphate per acre in addition to cake.
S S S
„ „ 4 receive 4 „ nitrate of soda and
S 2 „ superphosphate per acre.
Thus all plots marked S or S receive superphosphate at 2 md. per acre

PLATE XI.

Co. 210 on New Area, Pusa. Planted, February 1927 : Photographed, 15th June 1927.



Co. 210 on New Area, Pusa. Planted, October 1926 : Photographed, 15th June 1927.

(3) *Seasonal and cultural experiments.* The general method of planting sugarcane at Pusa has now been practically standardised. The usual distance of planting thick and medium canes is 3 ft. apart and for thin canes 2 ft. 6 in. apart. This enables all intercultural operations to be carried on with bullock cultivating implements.

October planting. Planting of cane in the month of October was carried on with the varieties Co. 210, Co. 213, Co. 214, Co. 275 and Co. 280. The results obtained show that cane planted in October ripens earlier than that planted in February, but in most cases this is not a practical proposition in Bihar, because there is great pressure of work in this period owing to the cultivation of all other *rabi* crops.

(4) *Collection of data regarding mosaic and other fungoid diseases and insect pests.* The Imperial Mycologist and the Imperial Entomologist are engaged in this investigation, especially with regard to mosaic which is receiving considerable attention from the Mycological Section. Full details will be found in the reports of the above Sections.

Cane outturn and its disposal. The total area planted with cane in Pusa during the cane season 1926-27 amounted to 42·67 acres and the total yield was 17,772 md. The average yield per acre came to about 400 md. Out of this total production, 13,067 md. were sold to the Samastipur Sugar Mill for crushing and 1,805 md. were distributed for seed. Out of the total seed-cane distributed, 680 md. were Co. 205 and some 870 md. Co. 214. Seed-cane of other varieties was also supplied in small quantities to those mentioned below :—

1. Mr. J. Watson, Kalimpong, Bengal, Co. 213.
2. The Superintendent, Government Farm, Muzaffarnagar, United Provinces, Co. 273, 275 and 300.
3. The Deputy Director of Agriculture, Sepaya, Saran District, Bihar, Co. 273 and 275.
4. The Deputy Director of Agriculture, Aligarh, U.P., Co. 273, 275 and 300.
5. The Bhicanpur Concern, Muzaffarpur District, Bihar, Co. 275, 273, 280, 290 and 287.
6. The Dowlatpur Concern, Darbhanga District, Co. 273, 275, 280, 281, 287 and 290.
7. The Darbhanga Sugar Co. Ltd., Lohat, Co. 273, 287 and 290.
8. Messrs. Finlay Fleming & Co., Sahmaw, Upper Burma, Co. 281, 287 and 290.
9. The Government Farm, Lyallpur, Punjab, Co. 287 and 290.
10. The Imperial Cattle Breeding Farm, Karnal, Punjab, Co. 287 and 290.

Besides, a few sets of Co. 290 were sent to Washington, U. S. A., and some sets of Co. 205, 210, 213, 214 and 281 to the Philippine Islands.

VII. Reclamation of waste land.

The levelling and reclamation of waste flooded land has now been completed. This, although flooded during the rains, is cultivated under irrigation during the cold and hot weather. It is cropped with berseem followed by maize, and grazed by the pedigree milk herd. The result of this treatment is that what was formerly rough sandy jungle is now the richest part of the farm. Part of it has been tested by the Bacteriological Section and shows nearly twice the nitrogen content as compared to the best farm land.

VIII. Machinery and implements.

The steam ploughing tackle worked throughout the year for 98 days. The analysis of output, etc. is contained in Table VI. The old tractors worked occasionally but are now nearly worn out. Several bullock implements were tried. It is evident as a result of extensive trials for a number of years that some of the English made bullock implements are superior to anything in the market. A considerable amount of data is now available as to the most economic equipment in the way of implements and machinery for a modern estate in India.

Table VI.

Details in round figures of the working of the steam ploughing tackle for the last 10 years.

Year	Labour	Fuel	Oil	Renewal and miscellaneous stores	Total working cost	Ploughing			Grubbing			Disc Harrow			Rolling			Total working days
						Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Rs.	Rs.	Rs.	Rs.	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	No.
1917-18 .	940	1,424	315	3,419	6,098	170	7	9	616	26	4	821	20	3	173	22	4	121
1918-19 .	934	1,656	482	1,064	4,136	373	8	4	668	21	1	606	17	2	540	21	1	145
1919-20 .	1,200	1,623	633	1,196	4,652	405	8	5	488	22	2	582	21	2	533	23	2	126
1920-21 .	1,450	2,140	588	1,764	5,942	445	8	6	480	22	2	633	18	3	386	25	2	131
1921-22 .	1,243	1,622	412	1,783	5,060	242	8	6	601	21	2	442	17	3	285	21	2	114
1922-23 .	1,278	1,464	483	2,137	5,362	373	8	6	507	21	2	470	17	3	334	23	2	112
1923-24 .	1,317	1,819	486	611	4,233	374	7	5	494	20	2	535	14	2	128	24	1	120
1924-25 .	974	1,498	410	1,048	3,930	359	10	5	320	18	2	324	14	3	166	20	2	87
1925-26 .	1,368	1,781	350	3,532	7,031	394	8	8	238	24	3	512	20	3	530	26	3	103
1926-27 .	1,152	1,490	237	1,648	4,527	438	10	5	208	25	2	513	18	3	410	27	2	98
Total .	11,856	16,517	4,396	18,202	50,971	3,573	82	59	4,620	220	22	5,438	176	27	3,485	232	21	1,157
Average .	1,186	1,652	440	1,820	5,097	357	8	6	462	22	2	544	18	3	349	23	2	116

IX. Pedigree dairy herd.

The strength of the dairy herd at the end of the year stood at 346 animals. The condition of the cattle throughout the period was exceedingly good and they had green fodder crops to graze upon for the full 12 months.

(*a*) *Pure Sahiwal herd.* Work with the pure Montgomery or Sahiwal herd was continued as usual. The standard for qualification in this herd is a lactation of over 4,000 lb. in ten months. Of the Sahiwal cows completing a lactation during the year 1926-27, the following are the best :—

Table VII.

Pure Sahiwal cows.

Sl. No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	(days)
1	Mirja 396	27-12-19	3	5,696	(304)
2	Mundri 389	11-8-19	3	5,449	(303)
3	Hanumati 399	10-2-20	4	5,406	(304)
4	Sampati 311	31-10-16	5	5,236	(304)
5	Chandra 456	27-10-22	1	5,109	(306)
6	Nasoorti 427	8-3-21	3	4,946	(304)

(*b*) *Cross-bred herd.* Work with the cross-bred herd originally produced by crossing pedigree Ayrshire bulls and rejected Montgomery cows was continued as in the previous year. The following are the best results.

Table VIII.

Half-bred cows.

Sl. No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	(days)
1	Polly 18	4-1-17	6	11,042	(304)
2	Pearl 130	4-12-22	1	9,928	(304)
3	Laura 98	9-8-21	2	9,817	(303)
4	Kitty 10	22-5-16	8	8,968	(304)
5	Nelly 13	27-10-16	7	8,217	(291)
6	Bella 23	3-3-17	7	7,728	(304)

Results will shortly be obtained from the procedure of covering cross-bred cows with a Montgomery bull. This seems to be more promising than breeding among the cross-breds, and there is an extremely nice lot of young heifers just coming into milk as the result of this former cross.

Yield of milk. The following Table gives the milk yield for the year under report. During the year somewhat less milk was sold as compared with last year, but more calves were raised.

AYRSHIRE PEDIGREE BULL "COULTON" OF THE PUSA HERD.

[Imported as a two-year old in 1925.]

Half-bred Ayrshire-Montgomery cows showing improvement in udders by using a strain of Ayrshire blood.

TABLE IX.

Statement of milk yield for the year 1926-27.

Month	MILK YIELD IN LB.			AVERAGE YIELD IN LB. PER DAY AND PER COW PER DAY					
				CROSS-BRED COWS		MONTGOMERY COWS		TOTAL OF CROSS-BRED AND MONTGOMERY COWS	
	Total of cross-bred and Montgomery cows	Cross-bred cows	Montgomery cows	Average per day	Average per cow per day	Average per day	Average per cow per day	Average per day	Average per cow per day
July 1926	38,277	22,040	16,237	711	19·2	524	13·8	1,235	16·4
August	35,564	17,849	17,715	576	18·6	571	13·6	1,147	15·7
September	31,726	15,035	16,691	501	18·6	556	13·6	1,057	15·5
October	34,027	18,910	15,117	610	21·0	488	12·2	1,098	15·9
November	37,517	24,194	13,323	806	22·4	444	10·8	1,250	16·2
December	38,314	25,895	12,419	835	22·0	401	9·8	1,236	15·6
January 1927	36,899	25,559	11,340	824	21·1	366	8·9	1,190	15·0
February	31,589	21,970	9,610	785	21·2	343	9·3	1,128	15·2
March	36,465	24,950	11,515	805	21·8	371	10·0	1,176	15·9
April	37,577	24,029	13,548	801	21·6	451	12·9	1,252	17·4
May	38,183	24,890	13,293	803	20·1	429	12·6	1,232	16·6
June	39,375	23,937	15,438	798	19·0	514	13·2	1,312	16·2
TOTAL	435,513	269,267	166,246	738	20·5	455	11·7	1,193	15·9
TOTAL FOR 1925-26	421,856	278,747	143,109	764	17·9	388	12·3	1,153	15·5
TOTAL FOR 1924-25	450,961	271,809	179,152	745	16·8	490	11·1	1,236	14·4

Percentage of cows in milk. Throughout the year the average percentage of cross-bred cows in milk was 68 with a maximum of 82 in June and a minimum of 50 in September. In the Montgomery herd 48 per cent. were in milk throughout the year with a maximum of 53 in January and August and a minimum of 39 in May.

Calf rearing. The percentage of mortality among the calves which were pail fed during the year was 13 per cent. as against 17 per cent. in the previous year and 13 per cent. in 1924-25.

Clean milk. By means of careful technique in handling cows and milk before distribution, every endeavour was made to keep the bacterial count of the milk as low as possible. According to the standard adopted by the Ministry of Health in Great Britain, certified milk, which is the highest grade, must contain less than 30,000 bacilli per cubic centimetre. During 1926 Pusa milk exceeded this only for a short period in the month of July. The rest of the year showed, according to the tests conducted by the Bacteriological Section, a very low bacterial count. The milk is sold without any pasteurization or cooling ; hence the capital involved is kept at a low figure.

Sale of milk. Part of the milk is sold in Muzaffarpur city, 22 miles distant, and is taken in by a Ford lorry. It was found that the condition remained good even during the hottest weather. Part of the milk is sold from a shop in the bazaar, and since this has been done, other shops have sprung up to the resulting advantage of the milk supply of Muzaffarpur city.

X. General.

Financial results. The following are the cash sales for the present year and the two previous years :—

Year	Farm produce	Milk and milk produce	Sale of cattle	Total
	Rs.	Rs.	Rs.	Rs.
1926-27	9,272	26,602	8,303	44,177
1925-26	1,534	29,415	11,217	42,166
1924-25	2,704	24,634	5,125	32,463

Auction sale of cattle. The following shows the prices obtained in the auction sale :—

No. of cattle	Description of cattle	Total price obtained	Average price per animal
		Rs.	Rs. A. P.
13	Montgomery cows . . .	2,450	188 7 0
5	Cross-bred cows . . .	1,645	329 0 0
19	Montgomery bulls, young bulls and male calves.	2,960	155 12 0
5	Cross-bred heifers . . .	495	99 0 0
4	Montgomery heifers . . .	510	127 8 0
4	Young bullocks . . .	225	112 8 0 (per pair)

Upkeep of fertility. The fertility experiment already referred to is one of the most important lines of work in the Agricultural Section. Little data is available in India on this subject. The experiment carried out here is on a sufficiently large scale to be thoroughly practical. The fertility of the land is kept up by means of the intimate combination of cattle-rearing with agriculture. The farm is heavily stocked and cattle which consume leguminous crops on the arable land. In other countries cattle rearing and beef production is an essential part of agriculture. In India arable farming and cattle rearing are practically divorced, and this is one of the main reasons why the standard of agriculture is generally at such a low level. The result of grazing a *kharif* pulse crop on the succeeding cold weather cereal is very striking. Two fields Chhoania and Mysore, totalling 45 acres, after pulse grazing gave an average of 23 maunds of oats per acre in 1923 and in 1926. In 1924 and 1927, after a *kharif* silage crop and a dressing with farmyard manure, they gave 10 and 18 maunds oats respectively. The corresponding difference in two other fields Nepauli and Phatak totalling 30 acres was 17 maunds in 1926 after *kharif* maize, and 24 maunds oats in 1925 after grazing. These are all unirrigated areas. Under irrigation, the results would be still more striking.

XI. Programme of work for 1927-28.

1. (*a*) Practical treatment of a pedigree dairy herd of Indian cattle and a pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire most suitable to Indian conditions.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the Pusa farm is used for the maintenance of the dairy herd. The rotation adopted aims at the upkeep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of :—

(*a*) Rotations.
(*b*) Crops for fodder, seed and silage.
(*c*) Implements and machinery.
(*d*) Technique of cultural operations.

3. Continuation of collection of data and results regarding the cost and capabilities of the steam-ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs for collection of data and working costs and for determination of most suitable types of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. Experimental work at Pusa—

(*a*) Rotational experiments.
(*b*) Trial of new varieties of crops, especially leguminous fodder crops.
(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.
(*d*) Trial of sugarcane varieties suitable for growth without irrigation, along with the Sugar Bureau.

6. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

7. *Touring and advisory.* Visits will be paid to provincial agricultural centres.

REPORT OF THE IMPERIAL DIARY EXPERT AND SECRETARY, CENTRAL BUREAU OF ANIMAL HUSBANDRY.

(William Smith.)

1. Introduction.

Mr. Zal R. Kothavala, B.Ag., B.Sc., N.D.D., held charge of the office of Imperial Dairy Expert from 1st July to 16th October 1926. I took over charge from Mr. Kothavala on the afternoon of 16th October, 1926, at Poona, on my return from leave.

Public interest in the dairy and cattle-breeding industry has been well maintained throughout the year, the outstanding feature of the period from the point of view of this Section being the visits of His Excellency the Viceroy and Lady Irwin to the Karnal farm in August and November, 1926, and the public meeting so ably presided over by His Excellency in Delhi in February 1927. There is no doubt whatever but that the deep interest taken by Lord Irwin in the cattle-breeding problem and the wise advice which he gave in his opening address at the Delhi meeting have quickened and stimulated the interest of the public in general and the land-owning classes in particular in the great work of the betterment of Indian cattle. Lord Irwin's address at Delhi was widely reported in the press and many enquiries for technical advice have come to this office as the result of the publicity given to his excellent speech and his visits to the Karnal farm. A 1,000-feet cinema film of His Excellency's visit to the farm in November was taken by the Publicity Department of the Great Indian Peninsula Railway. This has proved to be a most excellent picture and forms a valuable addition to the educational and propaganda films of this Section.

The demand throughout the year from all parts of the country for technical advice concerning dairying and cattle-breeding shows a considerable increase over that of any previous year, and these demands for every class of information bring home the urgent necessity for increased research and investigation particularly regarding the dairy factory section of our work. Little or nothing is known of the chemical and physical properties of the milk of the buffalo or its suitability for the manufacture of any kind of milk product.

During my absence on leave, Mr. F. J. Gossip, Superintendent, in this Section officiated as Assistant Imperial Dairy Expert, and in February 1927 he was appointed as Live-stock Officer, Government of Bengal. From the date of my return from leave, my Assistant Mr. Zal R.

Kothavala, B.Ag., B.Sc. (Edin.), N.D.D., has done the major part of the educational work, at the same time assisting me in the general administration and advisory work of the Section.

Central Bureau of Animal Husbandry.

I continued to act as Secretary of this Bureau throughout the year. The Board of Agriculture, 1925, unanimously recommended that the control of this Bureau be vested in an executive expert Committee representative of all the Provincial Governments and the larger States, and it is certain that little real progress can be made in the work of this Bureau until such a controlling committee is appointed. Pending the sanction of Government to the appointment of this Committee and with a view to having everything in readiness in so far as possible for its advent, information has been collected from all parts of the country as to the cattle conditions and lists have been prepared of cattle likely to be suitable for registration as the foundation stock for breed herd books. The following numbers of cattle have up to date been offered for registration :—2,239 Sahiwal, 672 Scindi, 1,555 Hariana, 40 Gir, 135 Kankrej.

Copies of forms of herd book, systems of milk recording and authenticating, and breed society rules have been obtained from all over the world, and the Bureau is in a position to commence the important work of the foundation of breed records in India as soon as the representative Committee referred to can frame rules and approve of procedure, and as soon as the Bureau is provided with the requisite staff to inspect and admit or reject the cattle offered for registration in the proposed herd books.

II. Training.

The second lot of students studying for the Indian Dairy Diploma at the Allahabad Agricultural Institute finished their term in December, and five of these sat for examination ; of these five, four passed. In addition to the above mentioned, 8 students who had failed last year were allowed to re-appear for the examination after a repeat course of six months and one student who had completed the necessary two years' residential course at the Institute ; of these 5 passed.

Seven students for varying periods of training from Muttra, Rangpur, Madras, Jammu, Kumaon and Coimbatore and 10 Dairy Diploma students of the Allahabad Agricultural Institute received technical instruction during the year at the Bangalore and Karnal farms and the Government Creamery at Anand.

One post-graduate student completed his course of training at the farms and the creamery under my charge during the year, and four post-graduate students joined for training in January 1927 and another in June 1927.

Mr. F. J. Warth, Physiological Chemist, and his staff continued their assistance in the training of the students and the examination of feeding stuffs for all the farms. I acknowledge the ready help and valuable advice so freely given by Mr. Warth at all times.

III. Work done for Local Governments, Indian States, Municipalities, and Advice given to the General Public in India and also to persons or Governments outside of India.

Bombay. At the request of the Secretary, Presidency Agricultural Show, this Section took part in the Bombay Agricultural Show held at Poona in October 1926, in that dairy products manufactured at the farms and the creamery under my charge were exhibited, also some cattle of the Imperial Cattle Breeding Farm, Karnal, were sent to this Show for demonstration. Besides, demonstrations were given in the manufacture of cheese and butter and the handling of pasteurized milk by the students of the Imperial Institute of Animal Husbandry and Dairying, Bangalore, taking part in the Show. The writer acted as a judge of cattle at the Show and my assistant Mr. Kothavala adjudicated in the butter making competitions.

Messrs. Polson Manufacturing Co., Bombay, were furnished with a complete scheme with a plan of a dairy factory, machinery specifications, and standard specification for the insulation of cold stores, for the manufacture of butter from the maximum quantity of milk available in the Anand District. Later on this company were enlightened as to the advisability of installing a milk condensing plant.

Mr. J. C. Edwards, Middle Colaba (Bombay), interviewed the writer in Bombay in February last and as a result of this interview he was furnished with a complete scheme with a plan of a dairy factory, machinery specifications, list of establishment, a note on insulation of cold stores, etc., for handling 20,000 lb. milk. This gentleman was also supplied with information regarding the present state of the *ghi* industry in India, and the results of experiments made by this department in the manufacture of *ghi* according to modern methods as compared with the usual country practice.

Hyderabad State. The Director-General of Agriculture, H. E. H. The Nizams' Government, interviewed me at Bangalore in May 1927 to discuss dairying and cattle-breeding matters in respect of the Hyderabad State.

Baroda State. The Director of Agriculture was in correspondence with this office during the year under report on dairy matters and the working of the dairy machinery lately installed at their cattle-breeding and Dairy Farm at Makarpura(Baroda), and at the request of this officer

I visited Baroda on 24th March, 1927, to see the machinery in working order, and whilst there I discussed with the Registrar, Co-operative Societies, the question of the formation of milk societies in the State in order to solve the problem of village unemployment, and as a result of this interview a note on co-operative milk societies was submitted.

At the request of the Baroda Pinjrapole Society, Mr. Kothavala supplied them with a detailed note on the working of cow protection societies together with a plan for dairy buildings and cattle sheds with sections and elevations, and lists of cost of cattle, establishment and equipment.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to firms, public bodies and individuals at Bombay, Bassein and Ghatkopar.

Bengal. The Livestock Expert to the Government of Bengal was advised regarding cattle-breeding matters.

At the request of the Director of Agriculture of that Presidency, the services of a qualified manager for the proposed cattle farm of Kumar Sarat Kumar Ray of Digapattia (Rajshahi) were secured, and the Kumar was advised as to the best means of improving the cattle of his zemindari and the district.

At the request of the Calcutta Co-operative Milk Societies' Union, I visited Calcutta on 4th December, 1926, in order to pass the dairy machinery lately erected at their Milk Depôt in Calcutta, and to advise them regarding the drawing up of village milk producers' schemes in the vicinity of Calcutta, and for this purpose a number of villages in the vicinity of Calcutta were visited. As a result of this visit necessary plans and specifications of a village milk plant were submitted. At the request of this society I selected and branded at Karachi in December 1926 six Scindi cows, two bulls, 4 buffaloes and 2 buffalo bulls.

At the request of the Chairman, Bengal Co-operative Credit Societies, I visited Darjeeling on 7th December in order to select a site for the proposed Co-operative Milk Depôt, and later on a complete scheme for the working of this depôt with building plans and machinery specifications, etc., were submitted. At the request of this officer, I also visited Dacca on 10th January, 1927, where I addressed a public meeting organized by the Municipality of Dacca, and attended two meetings of the Municipal Council and advised them regarding the milk supply of Dacca and submitted a note on conditions on which the Co-operative Societies' Industrial Union could undertake to organize the milk supply of Dacca with the help of the municipality.

At the request of the General Manager, Calcutta Pinjrapole Society, Mr. Kothavala selected at Karachi in August 1926, 3 pedigreed Hariana bulls for this concern. Later on this society was advised as to the best breed for milk production, and at its request I assisted its Manager

in selecting 8 Scindi cows and one bull at Karachi in December 1926. A list of lantern slides on cattle-breeding was also supplied to this society.

Mr. N. Bagchi, of Butter-range, Calcutta, was in correspondence with this office regarding dairying matters, and he was advised as to the conditions of service he should offer to qualified men for the manufacture of casein, condensed milk and butter.

Mr. Rnaldooh of Calcutta was advised regarding pig rearing and as to the advisability of running a pig farm near Calcutta.

Mr. Antonio Da Silva Neves of Calcutta was supplied with a copy of the compiled list of publications issued by the Provincial Agricultural Departments and this Section, as well as a list of photographs of pure bred Indian cattle, and the Cow Preservation League, Calcutta, were supplied with a copy each of the publications on cattle-breeding and dairying issued by this Section.

Madras. The Superintendent of the Kolar Gold Field Dairy Farm, Oorgaum, was in correspondence with this office on dairy matters, and at his request the Oorgaum Dairy was visited by Mr. Kothavala in July 1926, and the authorities were advised as to the further development of this dairy and a site was selected for silos as well as a plot for fodder cultivation. In March last the writer also visited this dairy at the request of the Superintendent of the Oorgaum Gold Mining Co., and as a result of this visit, drawings showing the suggested alterations to the dairy building, specifications for a refrigerating plant, dairy machinery, and transmission gear were submitted.

At the request of the Health Officer, Corporation of Madras, arrangements were made to demonstrate the care and handling of milk and milk products at the Health Week—13th to 20th January 1927—at Madras.

At the request of the Deputy Director of Agriculture, Livestock, Madras, 4 Murra buffalo bull-calves were supplied from the Bangalore Dairy Institute for use on the Hosur Cattle Farm.

At the request of the Zemindar of Kangundi (North Arcot), Mr. Kothavala visited his estate on the 22nd January, 1927, in order to participate in the cattle show organized by the Zemindar, at which a demonstration in clean milk production and butter making was given and dairy cinema films were screened. On this occasion the dry-stock farm of the Zemindar was also inspected and necessary advice given.

The Officer in charge of the Ustitampaty Agricultural Farm was furnished with a scheme with the necessary plan of buildings required to run a milk producing and selling concern with a small capital.

Mysore State. The Director of Agriculture, Mysore, was supplied with a tracing showing the arrangement of the machinery to be installed in their proposed dairy farm. Information and particulars regarding insulation of cold store were also provided.

The Livestock Officer, Mysore, was furnished with detailed information as to the breed, price, etc., of a good milch buffalo.

Travancore State. The Director of Agriculture, Travancore, was advised concerning suitable breeds of bulls from milking dams for use in his State.

Coorg. At the request of the Chief Commissioner in Coorg various stations of Coorg were visited by Mr. Kothavala in September 1926 with a view to make a cattle survey of the place, and as a result of this visit, a note on the improvement of cattle in Coorg was submitted. Later on, the request of the Deputy Director, Land Records and Agriculture, Coorg, for a note on the cost of putting into force the recommendations of Mr. Kothavala, was complied with.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to firms, public bodies and private individuals at Madras, Kuppam, Rajmundry, Bezwada, Vizagapatam, Saidapet, Neazved (Kistna) and Katuputur.

Punjab. The Inspector General of Prisons, Punjab, was supplied with a complete lay-out plan of a model dairy farm for a new jail.

The Director of Agriculture, Punjab, submitted to this office for opinion an application from the Indian Product Corporation, Lahore, for lease of land in the Nili Bar (Montgomery) for starting a dairy farm, and he was advised as to the conditions under which this request should be granted.

The Registrar, Co-operative Societies, Punjab, was given facilities at the Imperial Cattle Breeding Farm, Karnal, for preparing cinema films of weaning and rearing of calves from birth.

At the request of Mr. P. P. Gupta of Delhi, Mr. F. J. Gossip, Offg. Assistant to the Imperial Dairy Expert, visited Delhi in July last in order to advise him as to the suitability of the land offered to him for his proposed dairy.

The Proprietor of the Imperial Officers' Dairy Farm, Lahore, was advised as to the best type of cow-sheds to accommodate their cattle and the advisability of housing the cattle of the *gowallas* in a separate shed. A plan showing the lay-out of modern dairy farm buildings was also supplied.

Syed Mohamed Husain, M.L.C., of Shergarh, was furnished with a plan showing details of the construction of truss roof for his cow-shed.

Nabha State. At the request of the State authorities, their State Dairy at Nabha was visited by Mr. Kothavala in August, 1926, and recommendations were made as to its further development. Later on a pure bred Scindi bull was selected at Karachi for the State dairy in September, 1926.

I visited Nabha on 16th December, 1926, at the request of the State Administrator, to inspect the State Dairy there, and advised him regard-

ing the future working of this dairy. I also selected at Karachi 12 Scindi cows for this dairy in December, 1926. Later on, the services of a qualified Dairy Manager holding the Indian Dairy Diploma were procured for this dairy, as their dairy manager had resigned his post.

Kashmir State. The Chief of the Staff, Jammu and Kashmir State Forces, was supplied with plans of a suitable dairy building for accommodating 70 cows in milk, while the Superintendent of Dairies of H. H. The Maharaj of Kashmir was advised as to the best breed of cattle for the State Dairy.

Kapurthala State. A scheme received from the Director of Agriculture for establishing a cattle-breeding centre in the State was criticised in detail at his request and the helpful advice given.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to firms, public bodies and individuals at Lahore, Ludhiana, Gondlanwala (Gujranwala) Chamba, Delhi and Kotgarh (Simla Hills).

United Provinces. At the request of the Deputy Director of Agriculture in charge Cattle Breeding Operations, Muttra, arrangements were made for the training of Mr. Nand Singh, G.P.V.C., Inspector, Agriculture and Cattle Breeding, Etawah, by giving him a six months' course in dairy farming and animal husbandry at the Karnal and Bangalore farms and the Anand Creamery. Mr. Chandu Lal deputed by this officer last year completed his training by the end of July 1926. At the request of this officer arrangements were made to train Mr. Syed Athar, a Zemindar of U. P., in dairy farming and animal husbandry at the Bangalore Institute.

The Director of Agriculture, U. P., was advised as to the extent to which financial help should be given by Government to the Allahabad Agricultural Institute to enable them to re-equip their dairy section in order to bring it in line with the Bangalore Institute for teaching students for the Indian Dairy Diploma course.

Mr. P. S. Caprihan, Agricultural College, Cawnpore, was supplied with a complete scheme for the establishment of a dairy near Agra to accommodate 75 cows, together with the following documents :—(1) A note of probable capital cost, (2) Cost of milk production, (3) Plan of lay out of dairy buildings and cattle sheds, etc., (4) List of establishment required, and (5) Machinery specifications.

Mr. R. L. Verma, B.Sc. of Agra, was advised as to how he could best deal with technical difficulties in connection with his dairy business.

The proprietor of the Singhal Dairy Farm, Itwara (Agra), was advised as to the best method of treating and transporting large quantities of milk in good condition from distant villages for city consumption in Agra. Later on he was advised as to the best method of utilizing

separated milk in the Naini Tal District, and a note on the manufacture of casein was supplied.

The General Secretary, U. P. Cattle Improvement Association, was, at his request, permitted to print 5,000 copies of my lecture delivered at Delhi, for distribution in the province. A scheme for the establishment of dairy farms in the municipalities, received from this association, was criticised by me in detail and the needful advice given. Subsequently a detailed scheme for the establishment of dairy farms by the municipalities of the province was furnished with statements of capital cost, and estimated trading results, etc. Mr. S. K. Bose of Lucknow was advised in connection with milk pasteurization, and Mr. Shri Chand, B.Sc. of Agra, as to the best method of dealing with milk for transport from Dholpur to Agra.

Central Provinces. The Deputy Director of Agriculture in charge Animal Husbandry, Nagpur, was advised as to the best method of preserving surplus butter and cream in tins, in that he was enlightened as to the best method of sterilization, use of preservatives and the method of packing.

Dhar State. The Remount officer of the Dhar State was advised as to the advisability of feeding gram to stud bulls and as to its effect on the milking qualities of the progeny of bulls fed on gram.

Bihar and Orissa. The Executive Engineer, Central Division, Patna, was supplied with information regarding the installation of cold stores for the proposed Veterinary College Dairy Farm at Patna, and he was also advised as to the source of supply of cold store materials.

The Director, Civil Veterinary Department, Patna, was advised from time to time during the year regarding dairying and cattle-breeding matters, and at his request I visited Patna on 7th January, 1927, to inspect the site for the proposed College Dairy Farm at Patna and also to advise him on the spot in connection with the erection of dairy buildings, and as a result of this visit, a detailed report on the Phulwari site and also a note written by Mr. Quinlan and the writer indicating the urgent need for introduction of propaganda for casein manufacture in Bihar and Orissa were submitted to the Bihar Government. In response to these recommendations a scheme submitted by Mr. A. H. Spearman of Phulwari Sharif (Patna) for the demonstration of casein and glue manufacture was forwarded to the Director of Industries, Bihar and Orissa, with my remarks. Later on the Director of the Civil Veterinary Department was supplied with a set of account forms used at the Imperial Institute of Animal Husbandry and Dairying, Bangalore, for introducing at the College Dairy Farm, Patna.

The Director of Agriculture, Bihar and Orissa, was advised as to the suitability of using artificial udders for training unskilled persons in milking. This officer was also supplied with detailed information

concerning the coupon system in vogue in this Section for the sale of dairy produce.

Assam. At the request of Messrs. Barry & Co., Calcutta, the writer selected 4 Scindi cows and 2 bulls at Karachi in December last for their Tea Estates at Silonibari and at Tangla (Assam).

Mr. R. M. Purkaystha of Sylhet was supplied with a complete scheme with dairy plans, machinery specifications, etc., for starting a dairy farm near Sylhet for the supply of milk to the town.

Burma. Arrangements were made for the supply of a pure Scindi bull from the Bangalore Dairy Institute herd for the Agricultural College Dairy at Mandalay.

Verbal and written advice was given to many other officials and non-officials, but the names are too numerous to mention in this report.

Advice given to Foreigners.

The Managing Editor of the World's Butter Review, Alberta (Canada), was supplied with information in connection with the butter industry in India. A list of the principal butter manufacturers in India was also furnished.

The Director of Agriculture, Phillipine Islands, was given detailed information about the Scindi, Montgomery and other indigenous breeds of cattle.

The Cattle Expert of the Animal Husbandry Department of South Africa was given every possible assistance in his seeing the work done by this department. He was also given a general outline of the cattle-breeding work being done in India.

The Chief of the Bureau of Dairy Industry, U. S. A. Department of Agriculture, was furnished, at his request, with detailed information about the present condition of cattle in India and the prospects of registration of Indian cattle into herd books.

At the request of the Director of Agriculture, Ceylon, 4 Scindi cows and one bull were selected and branded for him at Karachi.

IV. General.

I visited Simla on 19th November in order to discuss with the Director of Farms at the Army Head Quarters the question of co-operation between this department and the Military Dairy Farms.

The Assistant Controller of Dairy Farms, Southern Circle, was advised as to the working of milk pumps. Colonel J. Matson discussed with me in Bangalore in March, 1927, the question of the period between calvings of half-breds, and records of certain half-bred cows of Bangalore Dairy Institute were supplied in support of my contentions.

Information regarding "milk fever" among Indian milch cows was supplied to the Director, Imperial Veterinary Research Institute, Muktesar.

A paper on dairying as an Indian Village Industry written by me was read at the Indian Science Congress held at Lahore in January, 1927.

My recommendations for the transport of young calves 3′ high at the shoulder with the parent cows both by passenger and goods trains free of charge were accepted by the Indian Railway Conference Association held in October, 1926.

I delivered a lecture, illustrated with cinema films, at the public meeting organized by this department for the development of the cattle-breeding and dairying industry in India on 21st February, 1927, at the Elphinstone Cinema, New Delhi. His Excellency the Viceroy presided at this meeting which was attended by the Maharajadhiraj Bahadur of Burdwan, most of the members of the Royal Commission on Agriculture, and a large number of members of the Council of State and the Legislative Assembly and prominent men of Delhi and the vicinity.

Eleven photographs illustrative of the work being done at the Karnal and Bangalore farms of this department were supplied for publication in the *Review of Agricultural Operations in India.*

A memorandum of work done by this Section on research in the cattle-breeding and dairying industry in India was submitted to the Agricultural Adviser to the Government of India in connection with the Imperial Conference on the Co-ordination of Agricultural Research to be held in London.

The following articles were written for publication in the " Journal of the Central Bureau for Animal Husbandry and Dairying " :—

(1) The Importance of Cattle-breeding and dairying Industry in India.
(2) Dairying as an Indian Village Industry.
(3) Co-operative Dairying in Bengal.
(4) Results of the experiment in *ghi* making.
(5) The need for a village dairy factory system in India.

I acted as a corresponding member of the International Cheese Committee formed for the purpose of drawing up regulations for the sampling, testing, and sale of cheese internationally. The suggestion of the Secretary of this Committee that India should become affiliated to the Federation has been communicated to the Agricultural Adviser to the Government of India.

V. Karnal, Bangalore and Wellington farms and Anand Creamery.

Karnal. Mr. F. J. Gossip was in charge of this farm up to the 25th February, 1927, when he was relieved by Mr. F. E. Traynor. Mr. S. Cox acted as Assistant Superintendent up to 10th January, 1927.

The policy of improving the herd of Thar-Parkar and Hariana cattle on dual purpose lines of draught and milk qualities and the developing of the Murra buffalo herd on the line of milk production has been continued.

Eleven Thar-Parkar, 28 Hariana cows, and 20 Murra buffaloes and 3 buffalo bulls were purchased during the year and added to the herd.

The health of the herd was fairly good throughout the year, but several of the most promising of the young cattle died of black quarter. All suitable animals were inoculated according to the serum simultaneous method by an officer sent from Muktesar for protection against rinderpest.

The crops of wheat and rice yielded by the farm lands during the year were fair but less than the previous year. Owing to continuous reduction from part of the areas worked on the *batai* (share) system and to the fact that the increase of the herd provides the farm with an ever increasing supply of manure, a further three hundred acres has been taken from the *batai* tenants and will in future be cultivated by the farm staff. With the advice and assistance of the Secretary, Sugar Bureau, trials were made in growing Coimbatore canes at the farm with a considerable degree of success, Co 213 giving particularly satisfactory results.

The farm has been freely used as an educational centre throughout the year. The visits of His Excellency the Viceroy and Lady Irwin to Karnal have been referred to elsewhere, and during the year the farm was also visited by many prominent agriculturists and members of the Legislative Assembly.

The farm buildings, roads, plant, etc., were maintained in good repairs throughout the year.

The following Appendices I—III are attached :—

(1) Receipt and Expenditure statement.
(2) Statement of outturn of grain, fodder, etc.
(3) Statement showing yield of all cows which completed their lactation period during the year.

Bangalore. Mr. F. E. Traynor was in charge of this farm up to 25th January, 1927, when he was relieved by Mr. A. Lamb.

The herd at Bangalore suffered during the year from the effects of the vaccination as a protection against Johne's disease referred to in my previous report, and the total loss up to date from this source is estimated at Rs. 30,555. Towards the end of the period, however, the remaining cattle which have been vaccinated appear to have got over the ill effects of this operation, and it is hoped that there will be no further material losses from this source.

The demand for the dairy produce by the military troops and hospitals again declined considerably during the period.

Apart from the deaths from vaccination for Johne's disease referred to, the herds were maintained in good health and the farm buildings and machinery were all maintained in good order and repair.

The health of the many students attending the farm during the year was excellent.

The farm was visited during the year by the Royal Commission on Agriculture in India and many prominent Indians including Mr. M. K. Gandhi and Pandit M. M. Malaviya. Mr. Gandhi paid some ten visits to the farm and took a keen interest in all the work being done.

The following Appendices (IV—VI) are attached :—

(1) Receipt and Expenditure Statement.
(2) Statement of outturn of grain, fodder, etc.
(3) Statement showing yield of all cows which completed their lactation period during the year.

Wellington. Mr. E. G. Whittick was in charge of this farm throughout the year.

The health of the herd was fairly good during the period. Contagious abortion was less prevalent than previously, and only a few animals succumbed to Johne's disease or were disposed of because of this complaint.

The area under cultivation has been considerably increased, and the aim of the management in this connection is in time to produce all the fodder required by the herd.

The records of the year show a further reduction in the military demands for dairy produce, but notwithstanding this, the improved health of the herd and the increased cultivation has resulted in improved financial results.

The buildings, plant and furnishings on the farm were maintained in thorough repair throughout the year.

The following Appendices (VII—IX) are attached :—

(1) Receipt and Expenditure Statement.
(2) Statement of outturn of grain, fodder, etc.
(3) Statement showing yield of all cows which completed their lactation period during the year.

Anand Creamery. Mr. A. Lamb was in charge of this creamery up to 17th January, 1927, when he handed over to Mr. S. Cox who proceeded on leave on 21st March, 1927, and was succeeded by Mr. M. C. Rangaswamy, I.D.D.

The creamery from a commercial point of view has worked under a serious handicap throughout the year, in that it was not known at any time whether it was to be retained by Government or returned to the Military Department, and consequently the creamery could not guarantee

supplies of produce to any of its customers and had in consequence to give up valuable standing orders for butter.

An experimental milk condensing plant was erected at the creamery during the period, and preliminary experimental work has been done in connection with the manufacture of condensed milk sweetened and unsweetened from village buffalo milk.

The creamery was utilized as a training centre to the fullest possible extent and valuable experimental work in connection with the manufacture of *ghi* was carried out by Mr. Kothavala and the Superintendent.

The creamery was visited by the Royal Commission on Agriculture in India in March last.

The Receipts and Expenditure statement for the year forms Appendix X to the Report.

APPEN

Statement showing receipts and expenditure of the Imperial

Heads of receipts	Total Receipts	
	Cash	Book debit
	Rs.	Rs.
Dairy produce		
On credit	7,810	4,594
On cash	1,482	..
Total	9,292	4,594
Capital receipts		
Live-stock (dairy)	3,124	1,680
Live-stock (draught)	45	..
Total	3,169	1,680
Miscellaneous receipts		
Sale of skins	61	..
Grain and fodder	43,465	4,516
Other miscellaneous receipts	6,396	2,014
Fees from students	2,055	25
Total	51,977	6,555
Grand Total	64,438	12,829
Combined Total	77,267	

DIX I.

Cattle-breeding Farm, Karnal, for 1926-27.

Heads of expenditure	Total Expenditure	
	Cash	Book debit
	Rs.	Rs.
Supplies and services		
Lands buildings and accessories	808	..
Plant and machinery	368	..
Purchase of dairy cattle	19,117	363
Purchase of draught cattle	900	..
TOTAL OF CAPITAL ITEMS	21,193	363
Rent and repairs to buildings	6,398	..
Repairs to plant and machinery	2,303	..
Feed of dairy cattle	20,903	67
Hire of cattle and purchase of dairy produce	1,498	725
Ice, salt and acid	2,279	26
Cultivation charges	5,430	10,430
Fuel, light, water and miscellaneous stores	2,834	4,444
Freight on stores	3,893	..
TOTAL OF REVENUE ITEMS	45,538	11,692
Contingencies		
Miscellaneous charges and refund of deposits	3,222	176
Establishment		
Pay of officers	4,859	..
Pay of other establishment	23,420	155
TOTAL	28,279	155
Allowances		
Travelling allowance of gazetted officers	1,962	..
Travelling allowance of non-gazetted officers	1,310	..
TOTAL	3,272	..
GRAND TOTAL	1,01,504	12,386
COMBINED TOTAL	1,13,890	

APPENDIX II.

Outturn of grain and fodder from the Imperial Cattle-breeding Farm, Karnal, during the year 1926-27 as compared with the two previous years.

Particulars	1924-25	1925-26	1926-27	Difference	
				Plus	*Minus*
Grain.	Md. Sr. Ch.	Md. Sr. Ch.	Md. Sr. Ch.	Md. Sr. Ch.	Md. Sr. Ch.
Gram (Seed)	1,085 22 0	266 5 8	0 12 8	..	265 33 0
Barley	122 24 0	86 17 0	138 5 8	51 28 8	..
Wheat	893 5 0	3,603 14 0	4,745 20 4	1,142 6 4	..
Ziri	3,071 26 0	5,096 12 0	3,056 1 4	..	2,040 10 12
Wheat and gram (mixed)	723 10 0	667 10 12	..	..	667 10 12
Mustard seed	21 24 4	31 28 0	..	..	31 28 8
Toria seed	..	37 19 8	26 27 2	..	10 32 6
Maize seed	43 27 0	3 38 0	45 20 0	41 22 0	..
Gua	287 38 0	85 21 0	346 7 8	260 26 8	..
Sugarcane seed	..	2,274 30 0	1,190 20 0	..	1,084 10 0
Pease seed	..	4 3 0	..	..	4 3 0
Jowar	..	..	10 0 0	10 0 0	..
Potatoes	..	..	29 17 0	29 17 0	..
Fodder.	lb.	lb.	lb.	lb.	lb.
Anjan grass seed	..	..	50	50	..
Chari (Green)	..	..	647,036	647,036	..
„ (Dry)	9,040	..	8,000	8,000	..
Feeding hay	69,320	10,320	122,973	112,653	..
Green grass	5,088	2,052,465	1,991,781	..	60,684
„ Oats	..	41,980	30,580	..	11,400
Rice straw	..	..	109,845	109,845	..
Bhoosa mixed	95,132	325,027	468,455	143,428	..
Green maize	..	..	10,000	10,000	..
Thatching grass	..	..	172,702	172,702	..

Total amount of rainfall during the year 1926-27 under report was 32·01 inches as against 38·84 inches in the previous year.

APPENDIX III.

Yield of cows which completed a lactation period at the Imperial Cattle-breeding Farm, Karnal, during the financial year 1926-27.

Animal No.	Name	Approximate age on 31st March 1927	Milk yield	Days in milk	Remarks
	Thar-Parkar breed.	Years	lb.		
1	Bonnie	9	3,472	259	
2	Honey	10	4,403	260	Died on 5th February 1927.
2	Do.	10	1,519	123	
3	Flaura	9	533	111	
6	Bright	10	80	40	
8	Margaret	10	2,413	276	
9	Gertie	9	2,980	274	
11	Hope	9	1,802	292	
12	Lassie	9	1,315	283	
12	Do.	9	1,956	222	
13	Hannah	9	1,476	285	
14	Lizzie	8	922	112	Failed on weaning.
15	Kate	9	2,827	306	
16	Bella	10	1,375	296	Not weaned.
16	Do.	10	441	99	
17	Pride	9	1,316	286	
17	Do.	9	197	57	Failed on weaning.
18	Ruby	9	1,119	178	Weaned this lactation.
19	Ida	9	1,518	307	Died on 7th Sept. 1926.
21	Girtie	9	2,508	349	
22	Jean	10	983	169	Failed on weaning.
22	Do.	10	169	48	
23	Bess	9	3,151	359	Not weaned.
24	Nell	8	505	92	Died on 10th April 1927.
27	Connie	9	1,824	304	
27	Do.	9	317	66	Weaned this lactation.
28	Biddy	10	1,756	277	
28	Do.	10	652	92	Do.
32	Ruth	10	3,642	300	Do.
33	Bibi	10	3,151	328	Not weaned.
35	Moire	9	500	64	Failed on weaning.
36	Jane	9	1,143	84	Died 26th July 1926.
37	Dhanbir	10	2,144	221	
37	Do.	10	1,618	151	
38	Dewan	9	5,353	382	
38	Do.	9	2,606	263	Weaned this lactation.
40	Mercy	9	42	14	Do.
41	Loyalty	10	2,016	299	Not weaned.

APPENDIX III—*contd.*

Yield of cows which completed a lactation period at the Imperial Cattle-breeding Farm, Karnal, during the financial year 1926-27—contd.

Animal No.	Name	Approximate age on 31st March 1927	Milk yield	Days in milk	Remarks
	Thar-Parkar breed—contd.	Years	lb		
42	Fife	9	1,868	210	
43	Organ	9	1,208	172	
44	Artiste	9	3,930	245	
45	Horn	9	3,362	265	
48	Asdal	9	614	153	Weaned this lactation.
49	Collean	9	1,948	279	Do.
49	Do.	9	129	49	
53	Mamre	10	4,350	291	
55	Dhana	10	386	105	
56	Bint	9	1,983	210	
56	Do.	9	961	141	
57	Malaga	9	1,406	288	
59	Pricilla	9	2,730	249	
61	Spinet	12	2,576	441	
62	Violet	10	915	393	Very ill at calving.
63	Laura	10	138	53	Do.
65	Patsi	11	3,128	310	
67	Nannhi	10	1,217	204	Weaned this lactation.
68	Eve	10	3,131	354	
69	Begam	10	991	225	Very ill at caving.
71	Nora	9	3,720	287	
72	Starlight	9	1,906	249	
75	Matchless	9	2,919	251	
111	Goddie	6	571	137	
112	Carrie	10	350	84	Not weaned.
113	Roma	7	1,285	313	Purchased 11th Nov. 1925.
114	Pearl	7	1,902	377	Do.
115	Della	6	1,372	413	Do.
116	Morna	8	1,611	400	Do.
116	Do.	9	1,052	117	
117	Waif	9	1,058	323	Do.
118	Charry	5	1,426	379	
119	Pomeroy	6	2,800	439	Do.
120	Jewel	6	3,640	364	
121	Bibbybat	8	1,309	315	Do.
122	Rodha	8	447	90	Do.
125	Rosa	8	1,890	367	Do.
125	Do.	8	240	66	Do.
126	Lachhmi	6	2,238	442	
127	Merica	7	2,807	460	Do.

APPENDIX III—*concld.*

Yield of cows which completed a lactation period at the Imperial Cattle-breeding Farm, Karnal, during the financial year 1926-27—concld.

Animal No.	Name	Approximete age on 31st March 1927	Milk yield	Days in milk	Remarks
		Years	lb.		
129	She	8	2,557	284	
130	Countss	8	1,150	207	
131	Maid	8	581	139	Purchased 5th May 1926.
132	Laura	7	2,146	336	
136	Banshee	7	1,182	198	
137	Ann	6	726	131	
146	Agate	3	462	200	
	Hariana				
73	Ada	10	638	81	
77	Carnation	6	1,403	40	
78	Dora	9	1,570	252	
79	Effie	9	1,117	179	
80	Fay	9	973	184	
82	Hanna	8	1,875	257	
83	Irises	9	2,318	271	
84	Jill	8	466	202	
85	Lila	8	515	55	
86	Mary	7	1,699	277	
87	Nettie	6	942	215	
88	Opal	7	132	46	Weaned this lactation.
90	Ruby	10	152	70	Destroyed 19th Oct. 1926.
91	Joan	9	1,492	221	
93	Maggie	7	1,456	223	
94	Milkmaid	9	572	250	
95	Buttercup	8	1,020	180	
96	Latchmi	9	216	88	
97	Susan	8	1,396	233	
98	Vic	8	470	200	Not weaned.
101	Anne	13	2,489	255	
102	Boreness	8	2,477	268	
104	Officer	6	740	166	
105	Betty	6	643	121	
106	Kate	6	895	181	
107	Rosebud	7	97	97	
109	Wonder	6	3,636	286	
110	Hope	6	2,497	277	
128	Rutherford	6	2,878	308	Purchased on 11th Nov. 1925.
138	Meg	6	52	59	
140	Rani	7	160	103	
141	Alpha	7	220	119	
143	Disdain	6	522	223	
144	Promise	7	556	225	
163	Ganga	5	111	45	Purchased on 4th Feb. 1927.
166	Doris	6	227	42	Do.

APPEN

Statement showing receipts and expenditure of the Imperial
1926-

Heads of receipts	Total receipts	
	Cash	Book debit
	Rs. A. P.	Rs. A. P.
Dairy produce		
On credit	78,203 13 8	5,274 3 0
On cash	5,942 10 0	..
On coupons	22,645 5 9	..
Total	106,791 13 5	5,274 3 0
Capital receipts		
Live-stock (dairy)	4,535 15 6	3,135 0 0
Live-stock (draught)	31 0 0	..
Plant and machinery	14 0 0	..
Total	4,580 15 6	3,135 0 0
Miscellaneous receipts		
Grain and fodder	243 7 3	561 15 3
Other miscellaneous receipts	3,412 8 8	1,835 8 10
Fees from students	2,030 0 0	..
Total	5,685 15 11	2,397 8 1
Grand Total	1,17,058 12 10	10,806 11 1
Combined Total	1,27,865 7 11	

DIX IV.

Institute of Animal Husbandry and Dairying, Bangalore, 27.

Heads of expenditure	Total expenditure	
	Cash	Book debit
	Rs. A. P.	Rs. A. P.
Supplies and services		
Lands buildings and accessories	392 4 0	..
Plant and machinery	2,773 3 0	..
Purchase of dairy cattle	2,171 3 0	4,797 3 9
TOTAL OF CAPITAL ITEMS	5,336 10 0	4,797 3 9
Rent and repairs to buildings	1,077 15 0	..
Repairs to plant and machinery	2,503 9 0	..
Feed of dairy cattle	40,393 1 0	519 8 0
Hire of cattle and purchase of dairy produce	6,824 13 0	16,436 9 0
Ice, salt and acid	555 12 0	62 0 0
Cultivation charges	926 8 6	..
Fuel, light, water and miscellaneous stores	7,605 6 0	2,218 14 8
Freight on stores	619 10 0	1,502 0 0
TOTAL OF REVENUE ITEMS	60,506 10 6	20,738 15 8
Contingencies		
Miscellaneous charges and refund of deposits	8,273 3 9	493 13 9
Establishment		
Pay of officers	7,687 2 0	..
Pay of other establishment	24,565 10 0	40 10 0
TOTAL	32,252 12 0	40 10 0
Allowances		
Travelling allowance of gazetted officers	1,285 7 0	..
Travelling allowance of non-gazetted officers	207 11 0	..
Honoraria, etc.	99 0 0	..
TOTAL	1,592 2 0	..
GRAND TOTAL	1,07,961 6 3	26,070 11 2
COMBINED TOTAL	1,34,032 1 5	

APPENDIX V.

Statement showing outturn of fodder from farm lands at Bangalore and Bommanpalli belonging to the Imperial Institute of Animal Husbandry and Dairying, Bangalore, for the year 1926-27.

Where grown	Kind of fodder	Outturn in lb.	Remarks
Bangalore	Green Guinea grass	368,430	Out of this 105,000 lb. were converted into silage and the balance issued as daily rations throughout the year.
	„ Lucerne	153,400	The whole was issued for daily rations throughout the year.
	„ *jowar*	1,152,700	Out of this 1,021,200 lb. were converted into silage and the balance issued as daily rations from Sept. to Dec. 1926.
	„ Sunflower	96,000	The whole of this was converted into silage.
	Dry *jowar*	47,000	Used for daily rations from Dec. 1926 to January 1927.
Bommanpalli	Green *jowar*	282,100	Out of this 272,900 lb. were converted to silage and the balance for daily rations during October 1926.

APPENDIX VI.

Yield of all cows and buffaloes which completed a lactation period during 1926-27 at Bangalore.

No. of cow	Breed	Age	Quantity of milk given during lactation	No. of days required for lactation
			lb.	
133	H. B. Ayrshire	18½	11,802	432
406	H. B. Ayr. Hansi	13	3,842	227
440	H. B. Ayr. Sahiwal	12	4,525	293
459	Do.	12	4,191	285
523	Do.	11	13,066	386
711	H. B. Ayr. Hansi	11	4,155	354
812	H. B. Ayr. Sahiwal	10	6,593	441
821	H. B. Ayr. Scindi	10	6,812	291
822	Do.	10	2,473	211
829	Do.	10	4,755	285
858	H. B. Ayr. Sahiwal	10	2,930	162
888	H. B. Ayr. Hansi	9	6,545	219
903	H. B. Ayr. Scindi	9	6,288	346
927	Do.	9	8,400	374
955	Do.	9	3,217	206
962	Do.	8	3,785	260
962	Do.	8	3,059	230
967	H. B. Ayr. Sahiwal	8	4,459	199
972	Do.	8	4,546	273
975	Do.	8	6,953	293
997	H. B. Ayr. Scindi	8	5,154	296
78A	Do.	10	5,254	414
179A	Do.	7	4,333	288
189A	Do.	7	7,303	336
218A	Do.	7	6,116	287
235A	Do.	7	3,390	329
236A	Do	7	3,636	262
243A	Do.	7	4,550	268
251A	Do.	7	5,913	271
268A	Do.	6	6,690	299
280A	Do.	6	3,984	274
308A	Do.	6	2,983	237
314A	Do.	6	5,604	334
326A	Do.	6	4,655	300
328A	Do.	6	3,932	273
332A	H. B. Ayr. Thar-Parkar	6	5,362	299
346A	H. B. Ayr. Scindi	6	7,427	367
359A	Do.	5	3,391	297
363A	Do.	5	4,653	306
364A	Do.	5	3,443	258
375A	H. B. × H. B. Ayr. Scindi Cross	5	1,576	171
377A	H. B. × H. B. Ayr. Scindi	5	3,584	295
378A	Do.	5	2,236	232
379A	Do.	5	4,454	296
388A	H. B. × H. B. Ayr. Scindi Cross	5	3,834	252
398A	H. B. × H. B. Ayr. Sahiwal Cross	4	5,331	512
2	Jersey	8	2,017	296
2	Do.	8	1,385	250
434	¾ Ayr. Hissar	13	9,312	445
786	¾ Ayr. Hansi	10	4,098	292
173A	¾ Ayr. Hissar	7	1,882	299

APPENDIX VI—*concld.*

Yield of all cows and buffaloes which completed a lactation period during 1926-27 at Bangalore—concld.

No. of cow	Breed	Age	Quantity of milk given during lactation	No. of days required for lactation
			lb.	
192A	¾ Ayr. Hissar	7	2,726	161
192A	Do.	7	1,901	216
226A	¾ Ayr. Scindi	7	4,654	270
301A	Do.	6	2,640	280
301A	Do.	6	2,129	213
309A	Do.	6	3,921	227
344A	Do.	5	4,374	301
353A	¾ Ayr. Sahiwal	5	4,617	237
372A	¾ Hols. Sh. Scindi	5	6,202	291
373A	¾ Ayr. Scindi	5	3,127	312
2	Scindi	9	3,577	267
4	Do.	10	2,349	191
5	Do.	10	2,425	255
7	Do.	10	3,840	299
8	Do.	11	2,650	251
12	Do.	10	1,680	216
13	Do.	11	4,191	341
16	Do.	10	2,335	281
17	Do.	11	2,184	255
20	Do.	9	5,242	247
21	Do.	9	4,227	263
26	Do.	9	2,139	192
29	Do.	11	3,338	223
31	Do.	11	3,539	275
32	Do.	11	1,119	207
33	Do.	11	2,333	212
36	Do.	11	3,192	257
38	Do.	10	2,571	278
39	Do.	9	2,421	232
41	Do.	10	2,712	241
			&219	80 aborted
48	Do.	5	2,636	287
49	Do.	7	1,612	222
50	Do.	7	2,149	222
51	Do.	7	2,185	233
52	Do.	7	1,498	153
			&833	139 aborted
53	Do.	7	2,491	285
54	Do.	7	2,222	222
55	Do.	8	2,992	285
56	Do.	9	2,353	222
57	Do.	8	2,085	287
58	Do.	8	2,106	201
62A	Do.	3	116	53
59A	Do. × T. P.	3	157	47
70A	T. P. × Scindi	3	582	89
Buffaloes				
5	....	10	4,878	383
11	....	9	2,403	172
12	....	7	1,714	189

APPENDIX VII.

Statement showing receipts and expenditure of the Imperial Institute of Animal Husbandry and Dairying, Wellington, for the year 1926-27.

APPEN

Statement showing receipts and expenditure of the Imperial for the

Heads of receipts	Receipts
	Rs. A. P.
Dairy produce	
On credit	47,957 2 3
On cash	10,659 10 0
On coupons	11,972 13 0
Total	70,589 9 3
Capital receipts	
Live-stock—	
Dairy	4,500 5 9
Draught	481 10 3
Plant and machinery	68 7 0
Total	5,050 7 0
Miscellaneous receipts	
Grain and fodder	1,256 0 0
Other miscellaneous receipts	2,715 1 11
Total	3,971 1 11
Grand Total	79,611 2 2

DIX VII.

Institute of Animal Husbandry, and Dairying, Wellington, year 1926-27.

Heads of expenditure	Expenditure
	Rs. a. p.
Supplies and Services	
Lands, buildings and accessories	2,039 13 0
Plant and machinery	5,701 6 0
Purchase of dairy cattle	7,753 3 3
Purchase of draught cattle	1,075 0 0
Total of capital items	16,569 6 3
Rent and repairs to buildings	634 13 0
Repairs to plant and machinery	259 6 6
Feed of dairy cattle	19,434 0 3
Hire of cattle and purchase of dairy produce	22,577 1 0
Ice, salt and acid	135 13 0
Cultivation charges	3,258 11 3
Fuel, light, water and miscellaneous stores	4,081 5 6
Medical stores	171 13 0
Freight on stores	3,332 14 0
Total of revenue items	53,885 13 6
Contingencies	
Miscellaneous charges and refund of deposits	1,384 11 6
Service, postage and telegraph charges	300 0 0
Total	1,684 11 6
Establishment	
Pay of officers	....
Pay of other establishment	18,270 12 0
Total	18,270 12 0
Allowances	
Travelling allowance of gazetted officers	....
Travelling allowance of non-gazetted officers	55 13 0
Honoraria, etc.	121 14 0
Total	177 11 0
Grand Total	90,588 6 3

APPENDIX VIII.

Statement showing outturn of grain and fodder crops of the Imperial Institute of Animal Husbandry and Dairying, Wellington, during the year 1926-27.

Name of dairy	Total area of the land in possession of the Farm			1926-27							Remarks
	Arable	Grazing	Building site	Total area of land under cultivation	Total outturn in green	Total expenditure incurred on cultivation	Production rate per 100 lb.	Total fodder purchased in green	Total amount paid for purchased fodder	Average purchase rate per 100 lb.	
	Acres	Acres	Acres	Acres	lb.	Rs. A. P.	Rs. A. P.	lb.	Rs. A. P.	Rs. A. P.	
								486,308	5,033 1 6	1 8 10	Purchased as dry fodder and reduced in terms of green.
Imperial Institute of Animal Husbandry and Dariying, Wellington.	15·10	40·61	6·08 Forest Land for Fuel 7·0	14·75	519,195	4,037 14 3	0 12 5	100,060	671 7 6	0 10 9	Purchased as green fodder

APPENDIX IX.

Statement showing yields of cows which completed a lactation period at Wellington during the year 1926-27.

Name and No. of cow	Breed	Age at end of the lactation period	Quantity of milk given during lactation	No. of days in milk	Previous yield	REMARKS
			lb.		lb.	
Rosie IV	Ayrshire	6	7,161	417	4,758	
Amber 1	Ayr. Scindi	18-3	8,436	505	8,676	
Debi 2	Scindi	7-6	1,880	177	..	Pur. in March 1926.
Sarathia 3	Do.	7-6	2,340	186	..	
Gangadevi 5	Do.	7-8	2,318	166	..	Pur. in May 1926.
Suseela 6	Do.	8-6	1,134	170	..	Pur. in March 1926.
Beryle 8	Ayr. Scindi	15-6	3,856	320	802	
Dropathia 9	Scindi	8-11	3,129	282	..	Pur. in March 1926.
Manakai 10	Do.	7-6	1,478	167	..	Do.
Brittania 11	S. H. Scindi	15-11	3,662	305	6,421	
Sarasvathi 12	Scindi	8-10	3,762	308	..	Do.
Rambai 13	Do.	7-4	1,317	126	..	Do.
Victoria 15	Ayr. Hausi	15-1	5,617	303	4,771	
Parvathi 16	Scindi	8	2,582	271	..	Do.
Kangai 17	Do.	7-8	1,558	236	..	Do.
Anne 18	Ayr. Scindi.	14-9	3,423	280	3,456	
Jessie 19	Scindi	7-6	2,098	177	..	Do.
Sakubai 20	Do.	7-4	760	79	..	Do.
Chandrabai 21	Do.	7-11	577	88	..	Do.
Ambai 22	Do.	7-11	2,341	179	..	Do.
Govindu 25	Do.	7-7	1,792	160	..	Do.
Jannakai 26	Do.	8-8	2,563	225	..	Do.
Milkmaid 27	Ayr. Scindi	13-11	8,560	498	1,447	
Nurbudha 29	Scindi	8-9	1,947	211	..	Pur. in May 1926.
Goonie 30	Do.	8-6	1,628	126	..	Do.
Jumna 31	Do.	7-8	1,355	249	..	Do.
Kaveri 33	Do.	7-5	593	87	..	Do.
Grace 40	Ayr. Scindi	13	6,150	341	9,528	
Doris 42	Do.	12-2	5,044	415	2,929	
Karani 44	Scindi	6-9	1,026	152	1,870	
Vimala 45	Do.	7-8	1,220	153	2,027	
Sita 46	Do.	7-6	53	42	1,133	
Rukmani 47	Do.	7-2	2,427	299	..	
Valli 49	Do.	7-7	303	90	468	

APPENDIX IX—*concld.*

Statement showing yields of cows which completed a lactation period at Wellington during the year 1926-27—concld.

Name and No. of cow	Breed	Age at end of the lactation period	Quantity of milk given during lactation	No. of days in milk	Previous yield	REMARKS
			lb.		lb.	
Ooma 50	Scindi	6-6	192	61	1,166	
Molly 110	Ayr. Sahiwal	12-2	3,919	295	3,437	
Pancy 111	H. B. S. Scindi	12-2	5,318	318	5,678	
Queen 112	¾ Ayr. Jer Scindi	10-4	2,771	273	5,034	
Pearl 114	Ayr. Scindi	9-3	4,076	328	4,295	
Ruby 116	Do.	9-2	4,605	296	7,715	
Emerald 117	Ayr. Sahiwal	8-10	7,208	319	5,665	
Helan 118	Ayr. Scindi	9-4	1,344	141	3,027	
Tulip 120	Ayr. Sahiwal	8-6	2,966	255	4,199	
Flossie 121	Ayr. Scindi	8-2	4,345	321	..	Aborted.
Nelly 123	Do	8-4	3,171	270	3,004	
Clara 124	H. B. × H. B.	4-3	2,881	278	2,932	
Benita 125	Ayr. Scindi	4-2	2,346	251	1,964	
Elizabeth 139	Do.	3-11	1,846	241	2,333	
Butter Cup 140	H. B. × H. B.	4-3	5,702	433	..	Heifer.
Mabel 164	Ayr. Scindi	3-5	1,314	201	..	Do.
Bluebell 171	¾ Ayr. Scind	3-6	2,510	259	..	Do.
Mary 209	¾ Ayr.	7-1	5,000	302	5,845	
Eileen 228	Ayr. Scindi	6-1	2,519	301	6,026	
Lavender 258	Do.	6-4	5,185	351	4,968	
Maude 415	Ayr. Hansi	11-11	6,327	329	6,714	
Sadie 590	Ayr. Scindi	10-3	3,276	254	3,147	
Bess 706	Do.	10	5,898	315	4,381	
Dolly. 709.	Ayr. Sahiwal	10-4	6,802	398	7,842	
Butterfly 838	Ayr. Scindi	9-7	1,879	237	4,157	
Cornflower 851	H. B. Ayr.	9-1	4,031	368	1,575	
Poppy 924	Ayr. Sahiwal	8-4	3,590	268	6,245	
Ivy 948	Do.	8-2	2,597	243	4,096	
Susie 957	Ayr. Hansi	8-5	4,169	266	3,432	

APPENDIX X.

Statement showing receipts and expenditure of the Government Creamery, Anand, for 1926-27.

APPEN

Statement showing receipts and expenditure

Heads of receipts	Total receipts	
	Cash	Book debit
	Rs. A. P.	Rs. A. P.
Dairy produce		
On credit	35,905 5 5	82,355 4 6
On cash	1,387 0 3	..
Total .	37,292 5 8	82,355 4 6
Miscellaneous receipts		
Other miscellaneous receipts . . .	5,030 6 3	2,274 1 6
Fees from students	525 0 0	..
Total .	5,555 6 3	2,274 1 6
Grand Total .	42,847 11 11	84,629 6 0
Combined Total .	127,477 1 11	

DIX X.

of the Government Creamery, Anand, for 1926-27.

Heads of expenditure	Total expenditure	
	Cash	Book debit
	Rs. A. P.	Rs. A. P.
Supplies and services		
Plant and machinery	921 6 0	..
Total of capital itmes	921 6 0	..
Rent and repairs to buildings	199 15 0	..
Repairs to plant and machinery	820 2 9	81 6 0
Feed of dairy cattle	..	..
Hire of cattle and purchase of dairy produce	81,794 12 0	..
Ice, salt and acid	1,362 4 6	12 4 0
Cultivation charges	..	..
Fuel, light, water and miscellaneous stores	11,518 10 9	145 0 0
Freight on stores	3,699 15 0	..
Depreciation on buildings, plant, machinery, etc.	8,497 0 0	1,436 3 2
Total of revenue items	1,07,892 12 0	1,674 13 2
Contingencies		
Miscellaneous charges and refund of deposits	591 0 0	1,023 7 0
Establishment.		
Pay of officers	4,735 7 0	1,646 5 0
Pay of other establishment	6,945 5 0	302 14 0
Total	12,271 12 0	2,972 10 0
Allowances		
Travelling allowance of gazetted officers	738 10 0	3 0 0
Travelling allowance of non-gazetted officers	635 7 0	..
Honoraria, etc.	..	..
Total	1,374 1 0	3 0 0
Grand Total	1,22,459 15 0	4,650 7 2
Combined Total	1,27,110 6 2	

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(F. J. Warth, M.Sc.)

I. Charge and Staff.

Charge. I was in charge of the Section throughout the year.

Staff. Mr. A. V. Iyer, First Assistant to the Physiological Chemist, was on privilege leave from 23rd May to 9th June, 1927, and Mr. N. C. Das Gupta officiated as First Assistant during that period. Two new posts of a Laboratory Assistant and a Fieldman were sanctioned from 1st April, 1927.

II. Extension and Improvement.

A new cattle shed and a barn have been erected during the past year. The barn was required for storing fodders used in experimental work. It has supplied an urgent need. The cattle shed is a large structure designed for carrying out feeding tests with cows and young stock. A further improvement in the conditions has been effected by enclosing all the buildings belonging to the Nutrition Section in one block. Three roomy paddocks have been fenced off within this area.

III. Laboratory Work.

The following is a list of the analyses completed during the year :—

Complete analyses—fodders	143	
Ditto fæces	102	
		245
Dry matter in fæces, urine, silage, grasses, etc.		2,944
Single nitrogen determinations :—		
Fresh fæces	430	
Urine	116	
Fodders including silage, etc.	61	
		607
Mineral analyses—foods, fæces, urine and grasses		113
Partial analyses of urine		58
Complete analyses of urine		60
Total		4,027

IV. The Work of the Section during 1926-27.

(*a*) *Experiments on the nutrition of growing animals.* The importance of this work was discussed in last year's report. During the present

year experiments with growing animals were carried out at Bangalore, Hosur and Karnal. At Bangalore an experiment in which guinea-grass was compared with sorghum silage gave interesting results. The data are very briefly summarized in Table I.

TABLE I.

Guinea-grass and silage experiment.

	Guinea-grass	Silage
Consumption of concentrate *	10·99	11·25
Ditto roughage *	15·27	15·00
Total consumption of dry matter	26·26	26·25
Average live weight, lb.	367	374
Average daily live weight increase, lb.	0·8	0·9
Average per cent. digestion of dry matter . . .	59·16	62·80
Average per cent. digestion of nitrogen	79·28	74·23

* In kilos dry matter per head per week.

In this experiment concentrate was fed in proportion to the live weight. Roughage was fed *ad lib* and the amount consumed was determined daily. The figures show that sorghum silage is eaten quite as readily as and produces results in no way inferior to, guinea-grass. This observation should be of considerable value in localities where green fodder is not available all the year round.

At Hosur experiments on spear grass silage and hay were continued. The silage this year was made from grass which was only three weeks old. It was thought possible that such material might form a complete ration for 18 months old stock. Accordingly, it was fed without concentrate to two lots of 8 animals for 11 weeks. This attempt was not a success. The animals only maintained themselves. Analysis showed that the material was much poorer in nitrogen than had been anticipated, and digestion and nitrogen metabolism experiments showed that the amount of nitrogen digested was barely sufficient to maintain a nitrogen balance. The digestibility of the fodder, however, was found to be good. A relatively small amount of cake added to such a feed should make it into an economical productive ration. This point will be tested in the near future. In the course of this work at Hosur, some

noteworthy observations on food consumption were made. The following tabular statement brings out the points to be noted :—

TABLE II.

Hosur experiments. Consumption (in kilos dry matter) per head per week.

1926				1927			
Silage .	26·25	Hay . .	18·65	Silage .	25·85	Hay . .	19·01
Concentrate	8·51	Concentrate .	8·51	Concentrate	..	Concentrate	8·68
Total	34·76		27·16		25·85		27·69

The amount of silage consumed, though it was fed *ad lib*, in both instances, remained the same whether concentrate was given in addition or not. This is a very peculiar result. The result with hay is also peculiar. The poor consumption of hay in 1926 was attributed to the pressence of spears. In 1927 the spears were removed and the hay was chaffed. The feeding results show that this improvement of the fodder did not bring about an appreciable increase in consumption. It appears therefore that the poor consumption of hay in 1926 cannot be attributed to the presence of spears as was thought at the time. These peculiarities in consumption deserve further attention.

At Karnal last year it was found that rice straw is a better winter feed than wheat straw. This year an elaborate experiment was carried out to test this point more fully. Three fodders were chosen, namely, wheat straw, dry *juar* (sorghum) and rice straw. Each was fed to two groups of calves receiving respectively 1·5 lb. and 1·0 lb. of concentrate per 100 lb. live weight. The average daily live weight increases for the six groups are shown in the Table III.

TABLE III.

Average daily live weight increase obtained at Karnal in 1926-27.

	1·5 lb. concentrate per 100 lb. live weight	1·0 lb concentrate per 100 lb. live weight
Wheat straw	0·94	0·40
Dry *juar*	0·98	0·84
Rice straw	1·07	0·70

The first point to note in this Table is that, with the higher concentrate allowance, all differences due to the roughage are obliterated. Growth is derived chiefly from the concentrate. With the lower concentrate allowance, *juar* and rice straw give much better results than wheat straw. The superiority of rice straw over wheat straw seems therefore to be clearly established. Between *juar* and rice straw there is not much difference. Last year rice straw was slightly better, this year *juar* is better. These small differences are probably accounted for by variations in the quality of the *juar*. The data relating to this point have not been tabulated yet. The Karnal experiment of 1927 has also yielded useful practical information on the question of concentrate rationing.

(*b*) *Indian coarse fodders. The digestibility of ragi straw* (*Eleusina coracana*). Determinations were carried out in a series of prolonged tests. The following Table gives a comparison between this year's results with *ragi* straw and last year's results with rice straw.

TABLE IV.

Comparison of ragi straw and rice straw.

	Dry matter	Organic matter	Ash	Crude protein	Ether extract	Fibre	Nitrogen-free extract	Total carbohydrates
Ragi straw, 1926—								
Composition per cent. .	100·00	92·49	7·51	3·24	·74	31·87	56·64	88·51
Digestion co-efficients .	58·22	61·70	..	..	..	70·15	61·01	63·99
Amount digested from 100 lb.	58·22	57·07	..	..	..	22·36	34·56	56·63
Rice straw, 1925—								
Composition per cent. .	100·00	82·41	17·59	2·70	·86	30·91	47·88	78·79
Digestion co-efficients .	53·54	60·61	..	11·17	43·41	70·43	57·71	62·53
Amount digested from 100 lb.	53·54	49·97	..	·31	·38	21·67	27·60	49·27

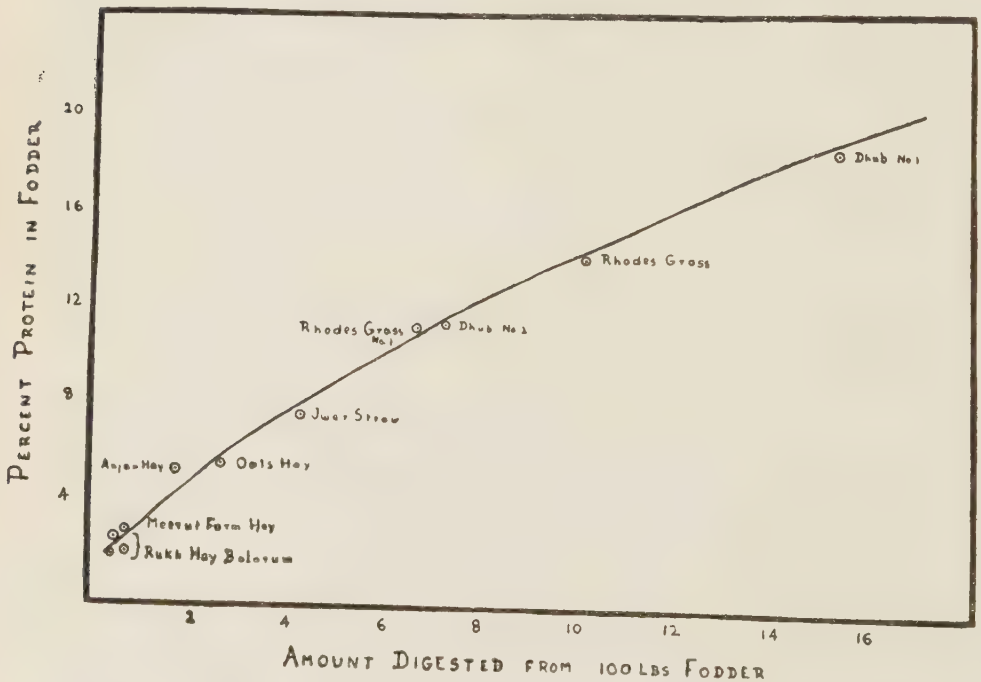
It is interesting to notice that the digestibility of the organic matter of these two straws is nearly the same, the digestion co-efficients being 61·7 for *ragi* and 60·6 for rice. But the rice straw contains very much more silica and ash, and hence much less organic matter than *ragi* straw. It thus comes about that, though the digestibility of the organic matter in the two straws is similar, the *ragi* straw actually provides much more nourishment. While there is such a serious lack of digestion data in India, the above facts may be of some use in estimating the nutritive values of other cereal straws. It should be mentioned here that *ragi* straw was found to induce diuresis, but the effect is moderate when compared with rice straw.

The digestibility of typical samples of Indian hay. Numerous hay samples from various parts of the country have been examined during the past eighteen months. Very great variations in quality have been noted. The nutritive values found ranged from 14 to 60 S. E. per 100 lb. dry substance. It is clear from these figures that, unless the quality of a fodder is known, the ration fed may be altogether wrong. The problem is a large one demanding some means for classifying hays. It is possible that a series of experiments, recently commenced, on the maturing of grasses may shed some light on this subject.

The digestibility of the protein of coarse fodders. An interesting observation has been made regarding the digestibility of protein contained in the coarse fodders which have been examined from time to time at Bangalore. It has been found that the digestibility is very nearly proportional to the percentage of protein in the food. The results are shown in the accompanying Chart.

CHART I.

A graphic representation of the relationship between protein content and digestibility.



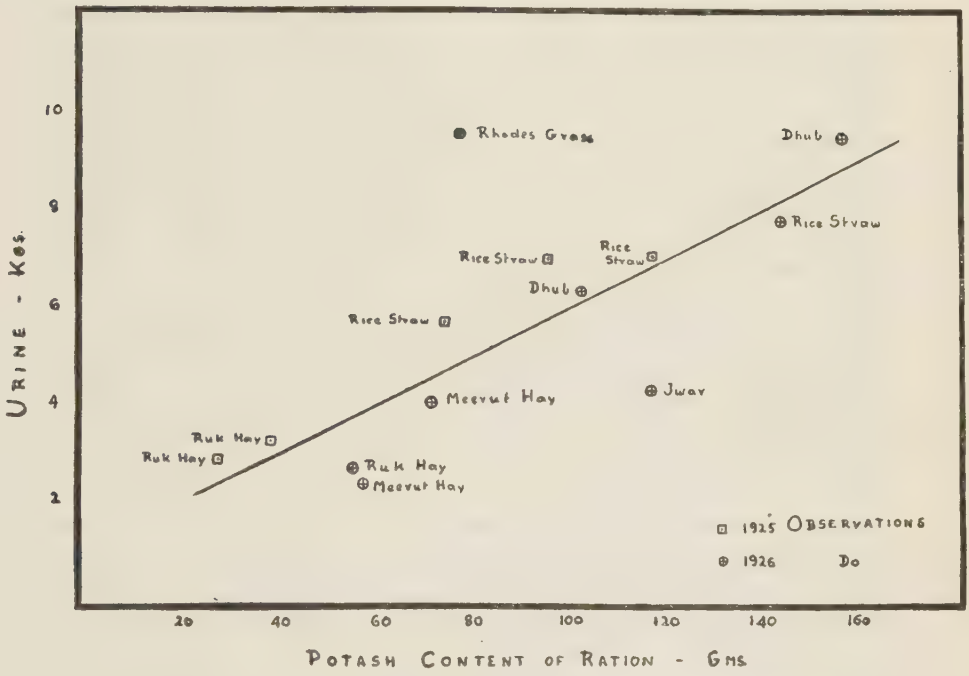
This is an interesting result which is at the same time useful, because it enables us to estimate the digestibility of protein in any fodder. Other

peculiarities connected with protein digestion have been observed recently ; for example, when comparing hay and silage it was found that the fæces of silage eaters invariably contained more nitrogen. These points are being studied more fully now.

Diuresis. The first observations on the diuretic effect of coarse fodders were mentioned in last year's report. Since then data have been obtained for a number of foodstuffs. The results are shown graphically in the chart below.

CHART II.

The relationship between potash in the food and diuresis.



This chart shows that with most of the foodstuffs tested during the past year, urination is largely dependent upon the potash content of the food. Two striking exceptions are worth noticing. In sorghum it appears that the potash effect is being buffered in some unknown way ; whilst in Rhodes grass there is present a more potent diuretic than potash. These points are receiving attention now.

(*c*) *Mineral requirements of cattle.* In recent years in other countries great improvements have been effected in the nutrition of animals by taking into account their mineral requirements. Cattle experts in India have not been slow to adopt similar measures and various reports of

successful mineral feeding have reached the Nutrition Section. The Nutrition Section itself has carried out a number of tests with young animals and with cows in milk. One experiment at Bangalore, with calves, gave figures which might possibly indicate some benefit from mineral feeding, but the result was doubtful. Other experiments carried out this year, with calves, showed no significant effect. In this case the need for minerals was certainly not so great as to show itself in three months. Unfortunately, the experiment could not be continued, and hence it is not known whether a less marked deficiency might not have revealed itself later. Experiments with cows at Bangalore have also given negative results up to date. This test has been in progress now for seven months, and it will be continued until a definite conclusion is arrived at. It should be emphasized that, in this question of mineral requirements, negative results are quite as important as positive. We have to find out the conditions under which sufficiency and deficiency respectively occur. Further, at a time when all cattle men are adding minerals to their rations, it is of economic importance to know that these minerals may not be necessary always. There must be many cases of mineral deficiency in India and they will no doubt be found and dealt with, if the enquiry is persisted in systematically. The Nutrition Section is making every possible effort in this direction.

(*d*) *Indian pasture grasses.* When the work on pasture grasses was taken up last year special emphasis was laid on the mineral aspect of the question. During the past year, accordingly, mineral analyses were carried out on a number of pure species grown in selected localities. Marked differences in the mineral constituents have been noted and these differences have been shown to be associated with distinct soil types. Further experiments have been initiated to determine the progressive changes which occur in the mineral and organic constituents during maturing. Finally, digestion experiments, with selected samples, are in progress to study the effect of ripening upon digestibility. It is hoped that the last named tests, besides providing specific data, will be a help in classifying Indian hays. It will be noticed that the samples are being used, as far as practicable, for studying the mineral problem and digestibility simultaneously. These enquiries are being carried out in co-operation with the Bombay and Madras Departments of Agriculture and the Military Grass Farms Department.

(*e*) *Experiments on milk production.* Work on this subject has been taken up again this year. The present experiments aim at the comparison of different breeds of animals. Small herds of cross-bred, Scindi and Ongole cows and Delhi buffaloes have been put on to a standard ration and determinations are being made of the capacity for food consumption, of the digestive capacity and of the milk yield of each group.

Another matter which is receiving attention is the rationing of dry pregnant cows. There seems to be a considerable amount of uncertainty on this point with reference to Indian cows. The Military Dairy Farms, in particular, have asked for information. Preliminary observations indicate that a surprising fall in consumption is likely to occur and this will have to be allowed for in the ration adopted.

The question of mineral requirements for dairy cattle is being studied at the same time with the Scindi herd.

V. Training of post-graduate students.

Post-graduate training has always been recognized by the Nutrition Section as an important part of its functions. Facilities for this work have been steadily increased and the Section can now provide a thoroughly practical course which comprises :—

(1) The carrying out of a feeding experiment under the direction of the Physiological Chemist.

(2) A course of lectures on animal nutrition given by the Physiological Chemist.

(3) A study of the nutrition work in progress here.

The student is put in charge of a number of animals. He has to care for them and work out their rations. He has daily practice in handling, observing and feeding live-stock and in systematic record-keeping. The Section has two qualified Veterinary Assistants whose duty it is to see that the health of the animals is duly attended to by the students. With the generous help of the Imperial Dairy Expert at its disposal, the Nutrition Section can provide all the animals and space needed for feeding tests. The post-graduate students have been working with 41 animals this year. Five students are undergoing training at present. Two students completed the course last year. The total number which have passed through since the course commenced in 1924 is nine.

VI. Instruction provided for Dairy Diploma Students.

Courses of lectures on chemistry (by an Assistant in the Nutrition Section) and on animal nutrition (by the Physiological Chemist) were provided as in past years for the Dairy Diploma students.

VII. Co-operation with other departments.

The following is a list of experiments which the Section is carrying out in co-operation with other departments :—

1. Madras Department of Agriculture. (*a*) *Feeding experiments at Hosur.* These experiments have already yielded valuable information

regarding spear grass silage and spear grass hay. Some mineral tests have been carried out and more work has been arranged.

(*b*) *Experiments with other grasses.* The necessity for this work was urged by the Nutrition Section. Two years of joint experience with spear grass emphasizes the importance of this line of enquiry.

(*c*) The Nutrition Section is greatly indebted to the Madras Department for the loan of a herd of Ongole cows for experimental purposes. The Nutrition Section hopes to be able to make some return for this courtesy by supplying the Madras department with information regarding the consumption and digestion capacities of this important Madras breed.

2. Bombay Department of Agriculture. The co-operative work referred to in last year's report on grazing area herbage has made a good start. It is being so considerably extended in scope this year that other work in Bombay cannot be undertaken at present.

3. Military Farms Department. Examination of Indian hay. Samples of typical hays and samples connected with ripening experiments are being provided by the Military Farms Department this year.

4. Imperial Cattle Breeding Farm, Karnal. The Karnal experiments have been described above.

VIII. Publications.

All the work which was completed before the end of 1925 has now been published. During the year one Memoir has been issued and one has been prepared for publication. The subjects dealt with are :—

1. Bangalore Maintenance experiments, 1st Series (1925). (*Mem. Dept. Agri. India, Chem. Ser.*, Vol. IX, No. 2).
2. Experiments on the feeding of Sorghum Silage (1925). (*Mem. Dept. Agri. India, Chem. Ser.* Vol. IX, No. 5).

The following articles have been submitted for publication in *The Journal of the Central Bureau for Animal Husbandry and Dairying in India* :—

(1) The rate of propulsion of food through the alimentary tract of ruminants. (Vol. I, Pt. I, April 1927).

(2) The capacities of Indian cattle for food consumption and digestion. (Vol. I, Pt. III, October 1927).

IX. Programme of work for 1927-28.

Major subjects.

1. Experiments on the nutrition of growing animals. This work involves tests at Bangalore and Hosur.

2. A study of Indian coarse fodders, including determinations of maintenance rations and studies of nitrogen and mineral metabolism. This is a continuation of the systematic work commenced during the past year at Bangalore.

3. Mineral requirements of young stock and cows. Experiments at Bangalore and Hosur are contemplated.

4. Examination of Indian pasture grasses. This work will be carried out in co-operation with the Military Dairy Farms and the Bombay and Madras Departments of Agriculture.

5. Experiments on milk production. A continuation of the work commenced this year.

Minor subjects.

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

Training.

1. The training of post-graduate students, which is an important branch of the work of this Section, will be continued as usual.

2. For the Dairy Diploma students a course in general science, plant, chemistry and nutrition will be provided by this Section.

REPORT OF THE GOVERNMENT SUGARCANE EXPERT.

(Rao Saheb T. S. Venkatraman, B.A.)

I. Charge and Staff.

I held charge of the office of Government Sugarcane Expert and Mr. N. L. Dutt of the post of Second Cane-Breeding Officer for the whole year. The Assistant Sugarcane Expert was in immediate charge of the bulk of the routine work including accounts.

II. Research and Investigations.

(*a*) *Cane-breeding technique.* The arrowing season for canes at Coimbatore coincides with the period of the North-East monsoon, and the prevailing rains used, sometimes, to adversely affect the seed setting in the cross pollinated arrows by washing off the stigmatic fluid or the pollen. The artificial rooting of canes which was evolved at the station during the last season has enabled the isolation of the arrows under cover in what have been termed 'hybridization sheds.' This is an advance of considerable importance in the technique of cane breeding. The opportunity to do a desirable combination presents itself only on certain occasions; and, in the past, a rainy day at the time used to prevent full advantage being taken of the opportunity.

The isolation of live arrows has also been found very suitable for carrying on cross-pollinations in a private plantation. A pully arrangement has been devised by which the pollinating arrow could readily be placed in any position that may be desired in the field.

The Coimbatore method of isolating live arrows after artificial rooting is reported to have been used with success at Florida. Dr. D. S. North of Australia has also written that he has found some use for the Coimbatore method in his disease studies of the sugarcane.

(*b*) *Root studies.* (i) *Powers of penetration.* The power of penetration of roots through various soils, the rapidity and nature of development and the depth of rooting as well as the lateral spread are some of the more important factors that determine the suitability or otherwise of a cane to a locality. The above studies received considerable attention during the year.

Young plants of thirteen different varieties were artificially thrown for their nourishment on one set or shoot root; and this was made to grow through different soil layers. Certain interesting data have been obtained; and it is proposed to repeat the experiment on a larger scale at some future date.

(ii) *Nature and mode of development.* The five Combatore seedlings now popular in Northern India, the leading indigenous Indian canes and *Saccharum spontaneum* were intensively studied for their root development under similar conditions for three months from germination. In the life of a cane plant, the first three-month period is one of considerable importance, sometimes a critical period in its life-cycle. The root-system developed during this period often plays an important role in the future development of the plant.

(iii) *Set versus shoot roots.* With the help of a method developed by the botany assistant, Mr. R. Thomas,* the functions of the two classes of roots in the early growth of the cane plant were worked out. In the course of these experiments, it was found possible to grow canes at a height of five to six feet from the ground, one or a few roots serving to connect the plants with the soil. The results of these studies are waiting to be written up for publication. Sugarcanes—those of the Noble class more than others—steadily go down in vigour and health and ultimately die, if the chance is not given to them to put forth fresh roots. In the case of *Saccharum spontaneum*, the roots possess a longer functioning period than in most canes.

(*c*) *Life-cycle of the sugarcane.* An intensive study of the cane plant, under Indian conditions during the various stages of growth, is rather a desideratum. Such a study is both important and necessary to fully understand and suitably supply its continuous needs. Any indication as to the composition of the cane plant previous to arrowing is further likely to lead to the inducement of arrowing in recalcitrant varieties—a factor of considerable importance in the breeding work at the station. A large scale experiment was laid out during the year to follow up the botanical and other changes in the life of the sugarcane. Four varieties —rather different from one another—are under study in this connection.

(*d*) *Germination studies.* In the cultivation of canes, a satisfactory germination is one of the first essentials. An early and lusty germination is often a great advantage in localities liable to pests. A large number of varieties were under study for their rooting characters previous to and during germination. Secondly, four varieties were studied in greater detail and at frequent intervals to try and analyse the factors responsible for good germination.

Observations on germination of varieties and seedlings, recorded during the previous years, were gone through to formulate ideas about the different factors involved. Under Coimbatore conditions, the largest number of germinations in the indigenous thin canes takes place between the twelfth and the eighteenth day after planting. Pansahi group is the earliest to germinate and is followed in order by Nargori Saretha, Sun-

* Thomas, R. A method of studying the roots of sugarcane. *Agri. Jour. India*, Vol. XXII, Pt. 2, March 1927.

nabile and Mungo. Pansahi, Nargori and Saretha may be classed as early germinators and Sunnabile and Mungo, as late.

(*e*) *Morphological descriptions.* With the spread into cultivation of certain of the Coimbatore canes, the need is being felt for popular descriptions of these to enable their identification in the field. Necessary data were collected with regard to the most popular five of these canes, including observations on rooting and germination. The information is waiting to be written up for publication. The Second Cane-Breeding Officer has worked out the hair group descriptions of these seedlings according to the Jeswiet system.

(*f*) *Arrowing and arrow fertilities.* The effect of soil and climatic condition on arrowing and arrow fertilities is of obvious importance in sugarcane breeding. The Nilgiri range of mountains is within easy reach of Coimbatore and possesses stations—agricultural or horticultural —at varying elevations. It was thought desirable to fully utilize this advantage in connection with the above studies. During the year an experimental plot of canes was planted at Kallar near the foot of the range through the kindness of the Curator. It is proposed to plant canes elsewhere as well, as facilities become available.

(*g*) *Selection of useful seedlings.* An important but rather difficult problem before the cane breeder is the selection of promising seedlings from among the widely varying lot before him. This becomes particularly difficult when, as at Coimbatore, the number of seedlings raised each year is large. As yet it has not been possible to definitely correlate early vigour with vigour at maturity. The elimination is therefore done very cautiously, as many as possible being grown for at least one year. The more promising of the selections are further planted in different soils before a definite rejection. The utility of all this caution was recently endorsed by the seedling Co. 281. This cane, while rather mediocre in its performance under stiff soil conditions, puts forth a remarkable growth in sandy loam with an admixture of ' red ' soil. The merits of this cane were first recognized after three years, when the test plots were planted in a soil suitable to it.

III. Performance of Coimbatore Canes in Out-stations.

The area under Coimbatore canes is steadily increasing in the Punjab, the United Provinces and Bihar. From the white sugar belt of Bihar, it has been reported that in certain parts the local cane " is fast going out and nearly all the European planters will plant nothing but Coimbatore canes this year." The reports of Provincial Departments of Agriculture are full of references to the performance of the Coimbatore canses.

One rather salient feature during the year has been the rapid spread of the Coimbatore canes in the United Provinces which have the largest concentration of cane area in India. The price of sugar during the year was particularly low and, but for the Coimbatore seedlings with their greatly increased yields, the Bihar sugar planters would have been badly hit. The frost in the Punjab was very severe during the year and while one of the local canes has been practically wiped out in certain places, the Coimbatore seedlings, intended to replace them, have stood the frost remarkably well.

Dr. F. S. Earle from Cuba writes, " Co. 281 is a very promising cane here... It is one of the richest in sucrose and earliest in maturity of any cane I have... It is also proving very resistant to root disease."

The following further Coimbatore seedlings are showing promise of future usefulness in one or other of the provinces :—Co. 204, 219, 237, 243, 244, 252, 272, 287 and 290.

IV. The Money Value of the Coimbatore Work.

It is only five years since the Coimbatore canes came into anything like general cultivation. The table below—the data for which were collected primarily for the Royal Commission—gives some idea of the benefits to the Indian sugarcane growers as a result of the Coimbatore work.

Province	Estimated acreage under Co. canes during 1926-27	Increased profit per acre from substituting Co. canes for indigenous kinds	Total increased profit to cane growers in the provinces
		Rs.	Rs.
The Punjab	3,600	50	1,80,000
United Provinces . . .	9,000	80	7,20,000
North Bihar . . .	11,000	50	5,50,000
Total .	23,600	..	14,50,000

Both the area under Coimbatore canes and the money value to the growers, it need hardly be said, are bound to steadily and greatly increase with the advance of time. The money value of the work to the growers during the year is over fourteen lakhs of rupees against a net recurring expenditure on the station of a little over half a lakh.

V. Receipt and Despatch of Canes.

During the year three fresh seedlings—two mediums and one thick—were added to the group of seedlings for trial outside. Thirty-two consignments of canes were sent out to fourteen places in India and to three foreign countries. Eight varieties were added to the collections at the station.

The import of canes from overseas has been rather limited during the last few years, chiefly because of the fear of introducing new diseases. Periodical literature was carefully examined for getting a list of successful canes outside and requests have been sent for importing planting material of useful canes. All such material is passed by the Government Mycologist and the Entomologist at the Madras Agricultural College before planting them at the station. Such imports are made with a view to keep at the station a stock of suitable parents. In the past certain of the importations have proved to have a limited use in certain localities.

VI. Research and Investigations under the Second Cane-Breeding Officer.

(*a*) *Thick cane breeding.* The breeding during the year was largely concentrated on the thick type of canes with the object of giving a good start to this branch of the activities of the station. After a careful examination of available data a scheme of crossing operations was drawn up and over 200 canes artificially rooted to enable the subsequent isolation of arrows for breeding purposes.

Though the arrowing during the season was satisfactory, the rains adversely affected the seed setting with the result that the total number of germinations during the season was only 13,000 against the usual 100,000 or more. After casualties during various stages of growth and transplantation, about 3,000 have been saved for being grown for a full year test at the new area acquired for this type of canes.

For breeding thick canes on anything like a large scale, it would seem desirable, in the first place to ascertain the factors responsible for the poorer germination among this type of seed as compared with those of medium or thin canes. The next season will be specially devoted to the working out of the factors responsible for good germination.

(*b*) *Germination of cane pollen in artificial culture media.* For success in hybridization operations it is obvious that it is desirable to have complete data, with reference to the male parent, as to the amount of pollen shed and, what is more important, the viability of that pollen at the time. Previous attempts at the station and elsewhere to germinate sugarcane pollen in artificial culture media have largely been more or

less of failures. Considering the importance of such germination in cane-breeding the problem was thoroughly gone into during the year.

After some experimentation a solution containing 26 per cent. sucrose and 0·7 per cent. agar was found to be a suitable culture medium. Very satisfactory germinations were obtained from various varieties and seedlings. The number of germinations obtained in one moist chamber was in certain cases over 2,000 ; and one of the seedlings at the station gave 61 per cent. germination in the above medium. Another rather striking feature in the germinations was the fairly long tubes—about 2 millimeters (2,000 microns) in length. This is very satisfactory considering the usual length of the styles and stigmas in the sugarcane.

The above results led to experiments being made about the time the pollen would retain viability when exposed to free atmospheric conditions. It was found that pollen did germinate after two hours' exposure to free air in the laboratory at 23°-25° C. It was further found that pollen would germinate even after exposure to direct sunlight at temperatures from 23°-30° C.

(*c*) *Separation characters in seedling canes.* With the spread of the Coimbatore seedlings into cultivation and with the great similarity that often obtains between closely allied seedlings, a need was felt for increasing morphological characters useful for distinguishing one seedling from another. An examination of the varieties and seedlings at the station showed that leaf arrangement and symmetry of the lamina halves would prove useful as additional separation characters.

The Jeswiet hair group system of classification was fully worked out with reference to the five popular Coimbatore seedlings.

(*d*) *Flowering habits of the thick type of canes.* A study was made of the flowering habits and other floral characteristics of a variety of parents likely to be useful in the breeding operations. Among the characters studied were—time taken for the complete emergence of the arrows in the different varieties, the time and duration of the opening of flowers, the time of the bulk dehiscence of the anthers in each variety and the interval between the full emergence of the essential organs of the flower and the bulk dehiscence of the anthers. The value of such observations to future crossing operations is obvious.

(*e*) *Cane nomenclature.* It is not an uncommon experience to find the same cane under two different names in different places. This results largely from an unfortunate tendency to rechristen a cane under trial and is not a little responsible for the present confusion in cane nomenclature. It should be left to the cane breeder alone to name his productions, because they are in the nature of new creations and no existing names will fit them.

When the same cane is grown under two different names it takes some time and certainly considerable trouble before the two can be

pronounced to be one and the same variety. The cane morphologist is in a comparatively disadvantageous position, because it is not always that the floral characters are available for definitely naming the cane. He has largely to depend upon the characters of the stem and leaf, and some of these show a certain amount of variation. About a dozen varieties—some of them under fancy names—are under study for various morphological characters.

VII. The Farm.

The new areas acquired last year were laid out into suitable blocks for cane cultivation. The area intended for thick cane breeding has yielded three blocks of about seven acres each for cane growing, exclusive of land for the laboratory, the cattle shed and other buildings.

The construction of residential quarters on the old area has slightly upset the arrangement of blocks and these are being redone. The recently acquired lands will need some special attention before bringing them into line with the rest of the area.

The receipts during the year amounted to Rs. 6,610, inclusive of Rs. 790 collected as house rent.

VIII. Miscellaneous.

The visitors during the year included Lord Linlithgow and the Members of the Royal Commission on Agriculture in India, the Hon'ble Member for Education, Health and Lands and the Hon'ble the Law Member of the Viceroy's Executive Council, and the Chief Minister to the Government of Madras. The Deputy Secretary to the Government of India, Education, Health and Lands, the Agricultural Adviser to the Government of India on two occasions, the Imperial Agricultural Chemist and the Imperial Mycologist also visited the station during the year. The last named officer came in connection with the mosaic situation at the station. My thanks are due to this officer as well as to the Government Entomologist and the Mycologist at the Coimbatore Agricultural College for ready help on all occasions. The Government Agricultural Chemist at Coimbatore has also been very kindly helping me with advice and with laboratory facilities when desired.

IX. Programme of Work for 1927-28.

Major.

The breeding of medium canes will be continued with the object of securing further improvements or covering new tracts.

The breeding of thick canes to suit the requirements of peninsular India will be carried on.

Further attempts will be made to improve the breeding technique and to secure greater germination among thick cane seeds.

Minor.

Studies on root development, on germination of sugarcane sets and germination of sugarcane pollen will be continued.

An intensive study of the cane plant during the various stages of its life-cycle, inclusive of rooting and tillering characters, will be undertaken.

Morphological studies of varieties and seedlings will be continued, as also of the flowering habits and floral characters of important parents.

X. Publications.

Venkatraman, T. S. .	Sugarcane Breeding—Indications of inheritance. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XIV, No. 3, 1927.
Ditto . .	Breeding improved sugarcanes for the Punjab. *Agri. Jour. India,* Vol. XXII, Part 4, July 1927.
Venkatraman, T. S., and Thomas, R.	Sugarcane hybridization sheds, forwarded to the world Convention of Sugar Technologists at Havana (Cuba).
Dutt, N. L. . .	Phyllotaxis and leaf-obliqueness as separation characters in seedling canes. *Agri. Jour. India,* Vol. XXII, Pt. 3, May 1927.
Thomas, R. . . .	A method of studying the roots of sugarcane. *Agri. Jour., India,* Vol. XXII, Pt. 2, March 1927.
Narayana Ayyar, L. K.	An improved pitting crowbar. *Agri. Jour. India,* Vol. XXII, Pt. 5, September 1927.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Wynne Sayer, B.A.)

Rao Saheb Kasanji D. Naik was in charge of the office of Secretary, Sugar Bureau, in addition to his own duties as Office Superintendent, till 9th October, 1926, when I took over from him on return from 6 months and 15 days' leave. The Bureau still continues on a temporary footing, the Government of India having sanctioned its further retention up to 31st March, 1929.

As in previous years, the collection of information relating to sugarcane cultivation, sugar manufacture and the sugar trade in India and abroad formed a part of the duties of this Bureau. The usefulness of the Bureau is being realized in an increasing degree and the provinces freely consult the Secretary. I have been made a member of the Sugar Sub-Committee of the Punjab Development Board and I have attended several meetings of that Committee.

With the introduction of improved Co. canes from Karnal and other centres in the south-eastern portion of the Punjab and the higher yields given by these canes in that tract, the question of disposing of the increased crop has assumed very urgent and practical importance. The cultivators' capacity for *gur*-making being limited, it would appear to their advantage to sell their green cane to a factory making sugar rather than convert it into *gur* themselves. This being the case, the establishment of modern sugar factories is the only solution that suggests itself.

In view of the hard canes with high fibre content which Indian factories have to deal with, any factories put up in North India should have not less than 14 rolls for crushing, and the staff as well as management will have to be thoroughly efficient if these factories are not to be squeezed out by the competition of outside sugars.

The drop in the price of sugar which has gone on steadily since the war is now being felt in certain tracts, notably that under the Deccan canals where the Bombay Government have asked for advice as to the best method to adopt to help the cane industry in this locality. Low prices bring the question of cane costs and the possibility of ratooning into prominence, and the work done by the Bureau on these points is now showing its value. The industry in the white sugar tract, which has always kept costs of cultivation at the lowest possible level is on its feet, and now it remains to be seen whether similar methods can be adopted to enable other sugarcane-growing tracts to meet the drop in prices.

I. Agricultural.

It was mentioned in last year's report that the Government of Bihar and Orissa had placed 4 Overseers under the Secretary, Sugar Bureau, for training in improved methods of cane growing and for propaganda work in the districts. On completion of their training, three out of these four were taken over by the Bihar Department of Agriculture this year. One Overseer now remains at Pusa who works under the supervision of the Secretary, Sugar Bureau, and goes out into the district in North Bihar wherever his services are required in connection with the introduction and improved cultivation of the approved canes from Pusa. During the year under report these Overseers visited some 40 concerns and examined about 6,500 acres of cane in over 140 villages and assisted the growers in various ways. There are fairly frequent calls for practical assistance and the presence of a trained Overseer enables me to render this promptly.

The growing of Co. canes Nos. 210, 213 and 214 sent from Pusa was started at the Karnal farm in 1924. This farm has a large area of lands suitable for cane and is eminently suitable for a demonstration and testing centre for cane work in the Karnal District. The Secretary, Sugar Bureau, rendered during the year under report assistance in the shape of technical advice to this farm. Co. 213 has grown on well at Karnal and it suffered far less from frost as compared with other varieties. The first large scale distribution of seed-cane was made in February 1927. Karnal is in an irrigated tract and Co. 213 yields heavily there. With sustained propaganda work this improved cane should replace the local varieties to the great benefit of the local growers. Co. 290 and Co. 287 are also under test there.

Small experiment plots for obtaining further data on the Co. canes tested out at Pusa were started at Lohat, Dowlatpur, and Bhicanpur, and will be put down at Lalsarayah this year. By such means it is hoped to obtain more definite data on growth than can be ascertained at Pusa alone. The increase of Co. 210 cultivation at the expense of Co. 213 in certain parts is a case in point, the data for which cannot be ascertained at Pusa where Co. 213 has always proved superior, but it definitely indicates that there are distinct soil differences in the tract affecting cane growth and demanding a different root system.

As a result of the arrangements made by the Secretary, Sugar Bureau, for the easy distribution of artificial manures through depôts in various centres, the manure selling agencies concerned have opened depôts and a campaign of demonstration has been started in the districts. The use of these manures is increasing in the cane area on this side. Further progress has been achieved in enlisting the assistance of central factories in demonstrating with and distributing these top-dressing manures for cane. It is necessary here to issue a warning particularly

for small growers whose cultivation is not sufficiently deep and the moisture in whose lands is consequently not so secure, that they should not apply these artificials to unirrigated cane before the break of the rains as otherwise the crop instead of deriving any benefit therefrom is likely to be damaged.

As a result of the experience gained so far, it may be definitely stated that the optimum distance between rows of canes in this part should be 3 ft. for medium thick canes like Co. 213 and 210, while it should be 2 ft. 6 inches for thin canes. This enables intercultural operations to be performed with ease and also helps to secure a good crop.

The method of planting sets eye to eye worked out at Pusa has now been adopted as a common practice by advanced growers.

The use of implements for intercultivation recommended from here is also now standard practice among good cane growers.

Mosaic. This disease is engaging the serious attention of the Mycological Section and such measures as are recommended are being adopted. Full details will be found in the report of the Imperial Mycologist for the year. As mosaic has been detected in the local variety Hemja, the aim at Pusa has been to find out canes which are immune or highly resistant to this disease and in this connection it is gratifying to be able to record that Co. 214 which is an early ripening cane with good sucrose content has so far not been found to be affected by mosaic. Several other varieties also are very promising in this respect, but their final distribution will depend on whether they are equally satisfactory from the agricultural and milling points of view.

II. Industrial.

The number of factories in India remained the same during the year under report. An important factory in the Bombay Presidency, *viz.*, the Nira Valley Sugar Co., was shut down, while a new concern, *viz.*, the Aira Sugar Factory in the Kheri District of the United Provinces began working for the first time this year. Among new floatations may be mentioned a private company under the title of the Hardwar Sugar Works and a joint stock company called the Maharaj Sugar Co., Cawnpore.

As in previous years, the Bureau continued to be in touch with the sugar factories in this country. The returns for the working season 1925-26 were obtained from all factories and refineries in India, and a consolidated statement of total sugar production in India was compiled and published in " The Indian Trade Journal " and " The Agricultural Journal of India." The production of sugar direct from cane in 1925-26 amounted to 51,867 tons as against 33,805 tons in the previous season ; the total quantity of sugar made from *gur* also rose from 33,593 tons

in 1924-25 to 38,407 tons in 1925-26. If we, however, take a review of the last seven seasons' production, we find that the refining industry is at a standstill, while the industry making sugar direct from cane is expanding. This will be clear from the following table :—

Year	Production of sugar		Total
	Direct from cane	Refined from *gur*	
	Md.	Md.	Md.
1919-20	628,920	1,211,274	1,840,194
1920-21	669,291	1,324,646	1,993,937
1921-22	753,638	1,303,433	2,057,071
1922-23	651,415	1,368,126	2,019,541
1923-24	1,044,856	1,538,304	2,583,160
1924-25	921,950	916,121	1,838,071
1925-26	1,445,061	1,047,420	2,492,481

This is as it should be. Out of the sugar actually present in 100 maunds of cane from which an efficient factory working direct with cane can obtain 10 maunds or more of sugar, a *gur* refinery working on its second hand material can barely hope to improve on 4-5½ maunds, as it starts work on a material which has already sustained a heavy loss of available sucrose. It is therefore obvious that competition between *gur* refining and straight cane milling is all in favour of the latter, and low prices for sugar such as are now prevalent mercilessly expose the weakness in *gur* refining as a method of obtaining sugar in competition with world prices. Further, sugar is a world commodity, the price of which is regulated by factors operating outside India, while *gur* which forms the raw material of refineries in India is a peculiarly Indian product and its price has no regular connection with the rise or fall in the price of sugar.

During the year under report the restriction of the Cuban crop of 1925-26 to approximately 4,885,000 tons, which was brought about by the decree of the President of that island, and the low yield of the Java crop due to the drought in the growing season, and the unseasonable rains in April and May, 1926, brought about a rise in the price of sugar in the world's markets which was also felt in this country. The price per maund of Java white sugar (ready) in Calcutta which was Rs. 10-11-0 on 1st January, 1926, rose to Rs. 12-14-0 on 1st June, then declined to Rs. 10-4-6 on 2nd August, but rose again to Rs. 11-1-6 on

2nd September, to Rs. 12-10-0 on 1st December and to Rs. 13-2-0 on 2nd January, 1927. Thereafter there was a decline. From Rs. 12-6-0 on 1st February the price dropped to Rs. 11-14-0 on 1st March, to Rs. 11-2-0 on 1st April, and stood at Rs. 10-11-0 on 30th June, 1927, Most of the factories in India which had sold their sugar forward reaped the benefit of the improved values. The present low price is due to the fact that the 1927 Java sugar crop is expected to show an outturn of over 350,000 tons more than the preceding year, while the area under beet in Europe shows an increase of 14 per cent. which may result in anything between a million and a million and a half more tons of sugar being available for consumption.

As in previous years a list of candidates seeking employment in Indian factories was maintained in the Bureau, and it is gratifying to record that a gentleman whose name was brought by the Bureau to the notice of the factories was given the appointment of Manager of an important refinery. A Chemical Assistant who was also recommended from here secured a job in a private factory.

III. Commercial and Statistical.

As by far the largest part of sugar consumed in India is in the form of *gur*, price quotations for various grades of this product were obtained from important *gur* markets in India, and these were forwarded to the Commercial Intelligence Department for record and publication in "The Indian Trade Journal." Quotations for Java superior white sugar at Soerabaya and for Cawnpore special sugar which is sugar refined from *gur*, as also the figures of stocks of sugar at the principal ports in India were regularly supplied to the same department for publication. Brief notes on the condition and prospects of the sugar crop in the principal cane-growing countries of the world were also compiled and furnished to that department for inclusion in their all-India sugarcane forecasts published in August, October and February.

Thirty-five notes giving statistical information regarding the production, exports, consumption, stocks, etc., likely to be useful to the sugar trade in India were contributed by the Sugar Bureau for publication in "The Indian Trade Journal."

The Sugar Cable Service which is financed by its membership of sugar firms and importers continued to function during the year. The experience gained from working this service during the last five years suggests the desirability of making arrangements to obtain daily quotations on the London Terminal Market and the fluctuations in the option bids on the New York Sugar Exchange from day to day, as these two markets exercise a growing influence on all sugar transactions and the course of prices throughout the world.

IV. Miscellaneous.

Library. During the year under report the library was strengthened with the addition of 196 volumes. These were obtained either by purchase, exchange or free supply or by binding loose copies of the periodicals received in the library. Books were issued to outsiders on loan against cash deposits received in the office. The well-known Sugar Technologist, Mr. Noel Deerr, and Dr. Haldane, Chief Chemist, Marhowrah Sugar Works, and others interested in sugarcane cultivation and sugar manufacture occasionally consulted the library.

Museum. Samples of sugar were obtained in the working season 1925-26 and these replaced the old ones in the Museum. Factories have been circularized for samples of sugar manufactured in the season 1926-27 and these when received will be duly exhibited in the Museum. A set of Java sugar samples is maintained to enable visitors and others to compare Indian made sugars with the correct Dutch standard of Java sugars.

Publications. Besides the 35 notes published in " The Indian Trade Journal," 3 notes were published in " The Agricultural Journal of India." A Review of the Sugar Trade in India during the year 1925-26 was completed during the year and has been published as a supplement to " The Indian Trade Journal," dated 21st July, 1927.

V. Conclusion.

The improved Co. canes tested by the Sugar Bureau and distributed in the white sugar tract have now been taken up on a large scale and the area under these canes in North Bihar alone this season is over 12,000 acres. They have already begun to find their way to the mills in this tract to such an extent that two factories now practically draw their entire crush from these canes, while in others these varieties form no insignificant proportion of the total supply. The increase in tonnage has given an increased cane supply to factories and this has enabled them to turn their attention to improvement in milling and boiling departments which were not justified when the cane supply was not assured. Eight roller mills are now being replaced with eleven and fourteen rollers for better juice extraction but there is considerable room for improvement in the boiling house efficiency. The presence of a group of factories where an already marked improvement in efficiency is steadily increasing, thanks to the efforts of Mr. Noel Deerr fully supported by his principals, is already exercising its influence on other factories who can now clearly realize what is possible with improved machinery working on their own cane instead of brushing aside the facts and figures as a printer's utopia—and inapplicable to North India. The formation of a Sugar Technologists' Association with its headquarters at Ghughli is an indica-

tion of a commendable desire for progress among sugar factory chemists and technologists. All such progress makes for the death of the old idea that any one can run a sugar factory, an idea which dies hard in India and nearly succeeded at one time in taking the industry to the grave with it. While there is no doubt, in reviewing the present position, that these improved canes have conferred the greater benefit on the grower than the mill (the increase in tonnage being greater than the proportional increase in sugar), this being necessitated by the fact that the grower being independent has to see his own advantage established first, yet the improvement in the cane supply has resulted in lower costs and better extraction and has justified improvements in plant which could not be undertaken with any doubt existing as to the supply of raw material. As the overhead costs are proportionately lessened and the earning power of the factory increased by the additional tonnage of cane milled, the advantages may be said to have been distributed and the industry as a whole to have reaped the benefit.

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